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STUDENT FLOW SIMULATION MODEL FOR NAVY CONSOLIDATED ELECTRONIC --ETC(U)
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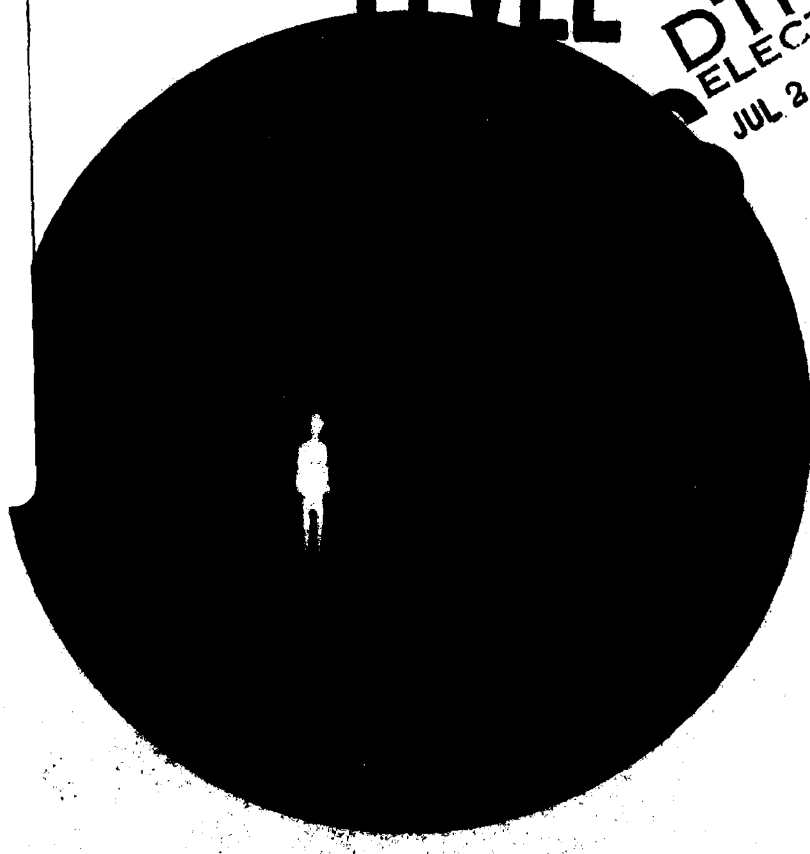

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STUDENT FLOW SIMULATION MODEL FOR NAVY CONSOLIDATED ELECTRONIC WARFARE TRAINING

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This report describes an applied training research study in the use of computer simulation being conducted for the Chief of Naval Education and Training (CNET) by the Training Analysis and Evaluation Group (TAEG). The study is a subelement of the Consolidated Navy Electronic Warfare School (CNEWS) training system program.

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The results of this applied research task should help improve the processes of planning, developing, and scheduling of training courses within CNEWS, including maintenance and operator training, officer and enlisted, common-core basic and advanced equipment-specific "C school" level courses, as well as individualized (self-paced) and lock-step (group-paced) training.

To achieve its purpose, TAEG was assisted by the University of Central Florida's Industrial Engineering and Management Systems Department who will develop the computer simulation model of EW student flow and CNEWS training resource/facility utilization during phase II of the study. When completed, the model will be used by the training command as a planning tool in support of further development and implementation of the CNEWS individualized training curriculum.

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SECTION I

INTRODUCTION

The Consolidated Navy Electronic Warfare School (CNEWS) is located at the Naval Technical Training Center (NAVTECHTRACEN), Corry Station, Pensacola, Florida. The CNEWS provides basic and advanced operator and maintenance training for officers and enlisted personnel. Twenty-four different types of students follow 14 separate training pipelines composed of various combinations of courses.

In May 1977, Chief of Naval Education and Training (CNET) assigned the Training Analysis and Evaluation Group (TAEG) the responsibility to develop a consolidated EW operator training curriculum for CNEWS. Once implemented, the new operator training system will provide students with individualized instruction using a variety of training resources. The Navy's Computer Managed Instruction (CMI) system will be utilized to manage the personnel undergoing training and the resources. Included in these resources are programmed instruction; narrative texts, sound-slide programs; random-access, interactive videotape programs; classroom and laboratory instruction; and training devices and operational equipment. A central component of the EW operator training system is a 60-student station generalized EW operator training device, Device 10H1. Appendix A provides a brief description of its characteristics.

The training pipeline structures at CNEWS are complex. Most officer trainees receive only operator training while most enlisted trainees receive both operator and maintenance training. For those students taking operator and maintenance training, this training is staggered; i.e., a phase of operator training is followed by a phase of maintenance training in an alternating fashion until completion of all required training at CNEWS. In this manner, students proceed through the respective learning tracks tailored to their specific needs. The new operator curriculum for CNEWS will be individualized and modular while maintenance training will remain traditional lock-step.

The overall complexity of the developing CNEWS training system presented several challenging problems to TAEG and CNEWS planners. Typical of these are (1) providing group-paced instruction in a variety of operator, maintenance, and technology courses using the school's current resources, (2) concurrently planning for the development and implementation of Device 10H1 and the new individualized EW operator curriculum, and (3) the fluctuation of student input rates causing periodic adjustment in quantities and types of training material, equipment, media, and training devices to assure smooth student flow to meet output requirements.

Solving the forecasting, planning, scheduling, and resource management problems at CNEWS requires assessment of numerous variables. The character of the problems precludes easy solution by traditional means. However, they are ideally suited to solution by computer simulation, and the solution provides an excellent management planning tool to aid in early identification of impacts which curriculum changes have on the current and future systems.

PURPOSE

The purpose of this report is to document phase I of a multiphased study designed to develop a user-oriented, predictive computer model of the CNEWS student flow. The overall model objectives are:

- be compatible for implementation on the Navy's CMI computer system (Honeywell 66/4400)
- provide the capability for planners to determine the maximum, minimum, and average expected times-to-train for each type of student as he/she progresses through the CNEWS
- provide the capability for planners to determine the trade-offs involved in the selection of one type of curriculum structure over another
- provide the capability for planners to determine the training material/media/facility requirements to meet output requirements in terms of a proper student mix.

Through the use of this model, the planners will be in a better position to make earlier determinations of the probable consequences of:

- increasing or decreasing the student throughput in terms of type or number
- introducing new types of instructional materials/media/devices/equipment/facilities
- changing either group-paced or individualized courses within the school's curriculum
- incrementally introducing new courses such as the individualized EW operator courses which may temporarily necessitate a dual pipeline for certain courses.

The purpose of phase I was to:

- define the modeling problem
- determine the types of data required for modeling
- collect the required data
- develop a document necessary to prepare a procurement package for developing and testing of the model(s) to be developed in phase II of the study.

Phase II will include the development and testing of the model in a batched-mode configuration. The results of this phase will be the subject of a subsequent TAEG report.

Phase III of the study will consist of the development of a user-interactive capability for the model, the development of a management information summary report output, and the installation, testing, and user evaluation of the model at CNEWS.

ORGANIZATION OF REPORT

In addition to this introduction, the report contains four other sections. Section II of the report describes current and planned EW operator and maintenance training pipelines at CNEWS that are to be simulated in the model. The pipelines are described in terms of types of students, their student flows (tracks) through the curriculum, course convening frequencies, the number of each type of student, estimated times-to-train for each lesson within a module, attrition and setback ratios expected for both group-paced and individualized training courses, and the predicted training resource requirements generated by these pipeline flows in terms of classrooms, laboratories, audio-visual equipment/materials, training devices/simulators, and operational equipment.

Section III describes the study method used to determine the approach for modeling the student flows through CNEWS and the rationale for selecting the particular simulation approach as the analysis tool.

Section IV describes the structure and design elements of the EW student flow simulation model. The structure and design elements will be developed in phase II. The levels of detail to be included in the simulation and the operational capabilities of the model are also described. The potential application of the model to other Navy technical training curriculum is also discussed.

Section V describes potential applications for the model.

SECTION II

CONSOLIDATED NAVY ELECTRONIC WARFARE SCHOOL DATA BASE

This section presents a short history of the CNEWS and describes its current and projected training program. The training program description includes a discussion of student input patterns, EW course descriptions, student flows (tracks) through courses in the curriculum, training facility, media/device/operational equipment utilization patterns, and school training management policies.

The narrative and tabular information contained herein for current operator, maintenance, and technology training and training projected for the new operator curriculum represents the data considered necessary to meet the computer simulation model objectives of the study task. The relationships found to exist among the various course data elements are identified and their allowable ranges, for modeling purposes, are defined. The data collection process is also described.

CONSOLIDATED NAVY ELECTRONIC WARFARE SCHOOL DEVELOPMENT

The CNEWS is in its third phase of development. The initial phase of development began in 1972 when the EW technician rating was established in the Navy and responsibility for the operation and maintenance of EW equipments was shifted from the radarman rating to the newly created EW rating. Requirements were identified at that time for courses of instruction to support the new rating, and funding was allocated for the construction of a consolidated EW training facility. During the second phase of development, 1974 to 1976, the EW school at Pensacola, Florida, was opened and consolidation of formal EW training in the Navy commenced.

From 1976 until the present, the third phase of CNEWS development has occurred. The basic common-core EW training pipeline was established using the Instructional Systems Development (ISD) concept. Training improvements initiated during this period included the development of random-access video tape instructional programs, the procurement contract for Device 10H1, and intensive modernization and update of existing EW operator, maintenance, and technology courses.

Phase IV of CNEWS will begin as the instructional system under development is implemented and with the planned procurement of a multistation training device for EW maintenance training. This phase of development is planned for 1982 through 1985.

CNEWS DATA BASE

In order to define and collect appropriate data from which a flexible and usable EW student flow model could be developed, a 2-day conference was held at TAEG in late May 1979. The purposes of the conference were to explore the data elements the model should include and to collect samples of this data. During June, July, and August 1979, data collection was completed.

Figure 1 resulted from the initial meetings with CNEWS personnel. Figure 1 shows the data base elements in terms of student inputs, the process via curriculum tracks, and the output required for model development. The input consists of three major types of students: officers, enlisted EW's, and enlisted personnel from other Navy ratings and other branches of the military. Some civilians and foreign military personnel undergo training at CNEWS, but their number is small, and for purposes of model development are not included. The student input considered for computer modeling consists of 7 categories of officers and 15 categories of enlisted/other students. Table 1 contains the definition for each of the student categories. To aid in data collection, the school's processes were defined in three major areas: (1) training course data, (2) training track data, and (3) training resource utilization. The training course data were subdivided into four areas: operations, maintenance, technology, and equipment-specific. Each of these areas was further subdivided into the additional categories shown in figure 1. For example, under training course data, the four major equipment-specific courses listed are: AN/WLR-1, AN/WLR-8, AN/SLQ-17, AN/SLQ-32. Likewise, the training track data and resource utilization data consist of 11 and 9 data elements, respectively.

All courses offered at CNEWS were identified by Course Data Processing (CDP) code, course long title, and length in weeks. This data is presented in table 2.

The current CNEWS training curriculum for enlisted students, which includes the majority of the students attending the school, consists of Basic Operations (CDP 602A) and EW Preventive Maintenance Technology (CDP 602B) courses, followed by one of the equipment operation courses as appropriate; e.g., AN/WLR-8 (CDP 018A) as shown in figure 2. All enlisted students then take the 3M Test Course (CDP 602C) followed by the appropriate equipment-specific preventive maintenance course. The enlisted students then take Advanced Operations (CDP 602D) and subsequently finish their training at CNEWS with one of the appropriate equipment-specific tactical operations courses. The student's equipment-specific courses are determined by his/her prospective duty assignment.

Twenty-nine enlisted student tracks were identified during data collection at CNEWS. For each enlisted student track, table 3 presents the categories of enlisted student(s) in the track and the courses and sequence in which each course in the track is taken. Seven officer student tracks were also identified at CNEWS. These tracks follow a general sequence consisting of Basic Operations Course (CDP 602A), followed by advanced operations and watchstanding/tactical operations courses appropriate for the student's subsequent duty assignment. Table 4 shows the forecasted officer and enlisted student input for CNEWS through FY 84.

Figure 3 provides a detailed flow diagram of the information depicted in table 3. This figure was developed to show the interrelationship of CNEWS courses and students that exists and that must be considered for student flow modeling. This figure will also be utilized subsequently in discussion of the curriculum for Device 10H1 and the changes that will occur in the CNEWS operator curriculum. The student track numbers from table 3 identify the various student paths through the curriculum diagram of figure 3.

INPUTS

Type Students

OFFICERS

- VQ - Pilot
- ASW-TACAIR
- EA6 PIPREP
- VQ Eval
- EA6 ECMO
- VAQ 33
- Marine EA6

ENLISTED EW

- USN 6YO
- USN 4YO
- USN Late Convertee
- USNR 4X10
- USNR 3X6
- Fleet Returnee (Operator)
- Fleet Returnee (Operator/Maintenance)
- Fleet Returnee ELINT

ENLISTED (OTHER)

- CTT ELINT
- CTM
- ETSU
- CTM 6YO
- AVEW
- Marine
- USCG

CIVILIAN

FOREIGN

PROCESSES

Curriculum Tracks

TRAINING COURSE DATA

Operations

- Basic
- Advanced
- Watchstanding
- Tactical

Maintenance

- Preventive
- Corrective

Technology

- Digital
- 3M
- Preventive
- Corrective

Equipment-Specific

WLR-1 WLR-8 SLQ-17 SLQ-32

TRAINING TRACK DATA

- Sequence
- Type Instruction
- Convening Period/Frequency
- Capacity
- Attrition/Setback Ratios
- Course Lengths
- Module
- Lessons
- Times-to-Train
- Classroom/Laboratory/Trainer Ratio
- CDP Number

RESOURCE UTILIZATION DATA

- Classroom
- Learning Center (Including Media)
- Classroom/Laboratory
- Laboratory
- Operational Equipment
- Training Device/Simulator
- Student/Instructor Ratio
- Student/Equipment Ratio
- Cross-Utilization by Courses

OUTPUTS

- Multi-year Requirements for Graduates by Student Type
- Course Operation Reports
- Student Time-To-Train
- Queues

Figure 1. Consolidated Navy EW School Student Flow Simulation Data Base Elements

TABLE 1. CATEGORIES OF CNEWS STUDENTS

OFFICERS

1. USN Fleet Air Reconnaissance Squadron (VQ), Pilot/Navigator (PIREP) EA-6B Aircraft
2. USN Aviation EW Officer (ASW/TACAIR)
3. USN EA-6B Squadron, Fleet Replacement Pilot
4. USN Fleet Air Reconnaissance Squadron (VQ), EW Evaluator
5. USN EA-6B Squadron, Fleet Replacement NFO (ECMO)
6. USN Fleet Squadron (VAQ-33) NFO
7. USMC EA-6 Aircraft Squadron, Aviation EW Officer

ENLISTED

1. USN 6YO - U.S. Navy 6 years obligated active duty convertees from other ratings (SCORE/RESCORE Program and personnel in advanced electronics field (AEF))
2. USN 4YO - U.S. Navy 4-year obligated active duty
3. USNR 3X6 - U.S. Navy Reserve 3 years active duty, 6 years inactive duty
4. USN LATE CONV - U.S. Navy late convertee from other ratings
5. USNR 4X10 - U.S. Navy Reserve 4 years active duty, 10 years inactive duty
6. FLT RETURNEE OPERATOR - Active duty personnel from Fleet for operator training only
7. FLT RETURNEE - OPERATOR/MAINTENANCE - Active duty personnel from Fleet for operator and maintenance training
8. U.S. COAST GUARD - Enlisted
9. CTM - U.S. Navy cryptologic technician (maintenance)
10. CTT ELINT - U.S. Navy personnel from the Fleet reporting for electronics intelligence (ELINT) training, cryptologic technicians (CTT), and U.S. Marine Corps active duty enlisted
11. ETSU - U.S. Navy electronics technician (submarine)
12. CTM 6YO - U.S. Navy cryptologic technician (maintenance) 6 years obligated active duty.
13. AVEW - U.S. Navy fleet inputs for aviation EW training
14. U.S. Marine Corps enlisted
15. Fleet returnee ELINT
16. Civilian
17. Foreign

TABLE 2. CNEWS COURSES BY CDP NUMBER, TITLE, AND LENGTH

Officer EW Courses

CDP Number	Title	Length/ Weeks
6474	VQ-Pilot Navigator EW Course (VQ PIREP)	5
6475	Aviation EW Officers Course (EWO) (ASW/ TACAIR)(PIREP)	3
9795	EA-6B Fleet Replacement Pilot EW Course	5
9797	Fleet Air Reconnaissance EW Evaluator Course	18
9798	EA-6B Fleet Replacement NFO ECMO Course	18
9799	VAQ-33 NFO Fleet EW Support Course	18
9928	EA-6 Marine Aviation EW Course	18

ENLISTED EW TECHNICIAN

Type Training	CDP Number*	Course Title	Length/ Weeks
Basic Operations	602A	EW Technician Class A School Basic EW Operations	4
Maintenance and Technology	C1*	Preventive Maintenance Technology	10
	015A	AN/WLR-1 Operator-Equipment Operations	1
	016A	AN/SLQ-32 Operator-Equipment Operations	1
	017A	AN/SLQ-17 Operator-Equipment Operations	1
	018A	AN/WLR-8 Operator-Equipment Operations	1
	602C	3M System/Test Equipment Training	2
	015B	AN/WLR-1 Operator-Preventive Maint.	2
	016B	AN/SLQ-32 Operator-Preventive Maint.	2
	017B	AN/SLQ-17 Operator-Preventive Maint.	2
	018B	AN/WLR-8 Operator-Preventive Maint.	2
	C2*	Corrective Maintenance Technology	5
	C3*	Digital Technology	4
	015D	AN/WLR-1 ESM System Maintenance	11
	016D	AN/SLQ-32V2 ESM Maintenance-AN/UYK-19	3
	017D	AN/SLQ-17 Maintenance-AN/UYK-20	4
	018D	AN/WLR-8 Maintenance	11
	412M	AN/ULQ-6 Maintenance	4
	016E	AN/SLQ-32V2 ESM Maintenance-System	6
	017E	AN/SLQ-17 Maintenance	18
	016F	AN/SLQ-32V3 ECM Maintenance	3
	604C	Submarine Electronics Technician EW Technology-Commun./Radar Theory	3
Advanced Operations	602D	Advanced EW Operations	3
	015C	AN/WLR-1 Operator-Tactical Operations	2
	016C	AN/SLQ-32 Operator-Tactical Operations	2
	017C	AN/SLQ-17 Operator-Tactical Operations	2
	018C	AN/WLR-8 Operator-Tactical Operations	2
	3197	Cryptologic Technician-Field Type 4/ Class A (ELINT Operator)	12

*C1,C2,C3 - Multiple CDPs used for these three courses to identify various categories of students attending.

C1 Preventive Maint. Technology	C2 Corrective Maintenance Technology	C3 Digital Technology
602B EW Technician Preventive Maintenance Technology	603A EW Technician Corrective Maintenance Technology	603B EW Technician
604A Submarine Electronics Technician EW Preventive Maintenance Technology	604B Submarine ESM Electronics Technician EW Maintenance Technology	604D Submarine ESM Electronics Technician EW Technology
605A Cryptologic Maintenance Technician (CTM) Preventive Maintenance Technology	605B Cryptologic Maintenance Technician (CTM) Corrective Maintenance Technology	605C Cryptologic Maintenance Technician (CTM) Electronics Technology

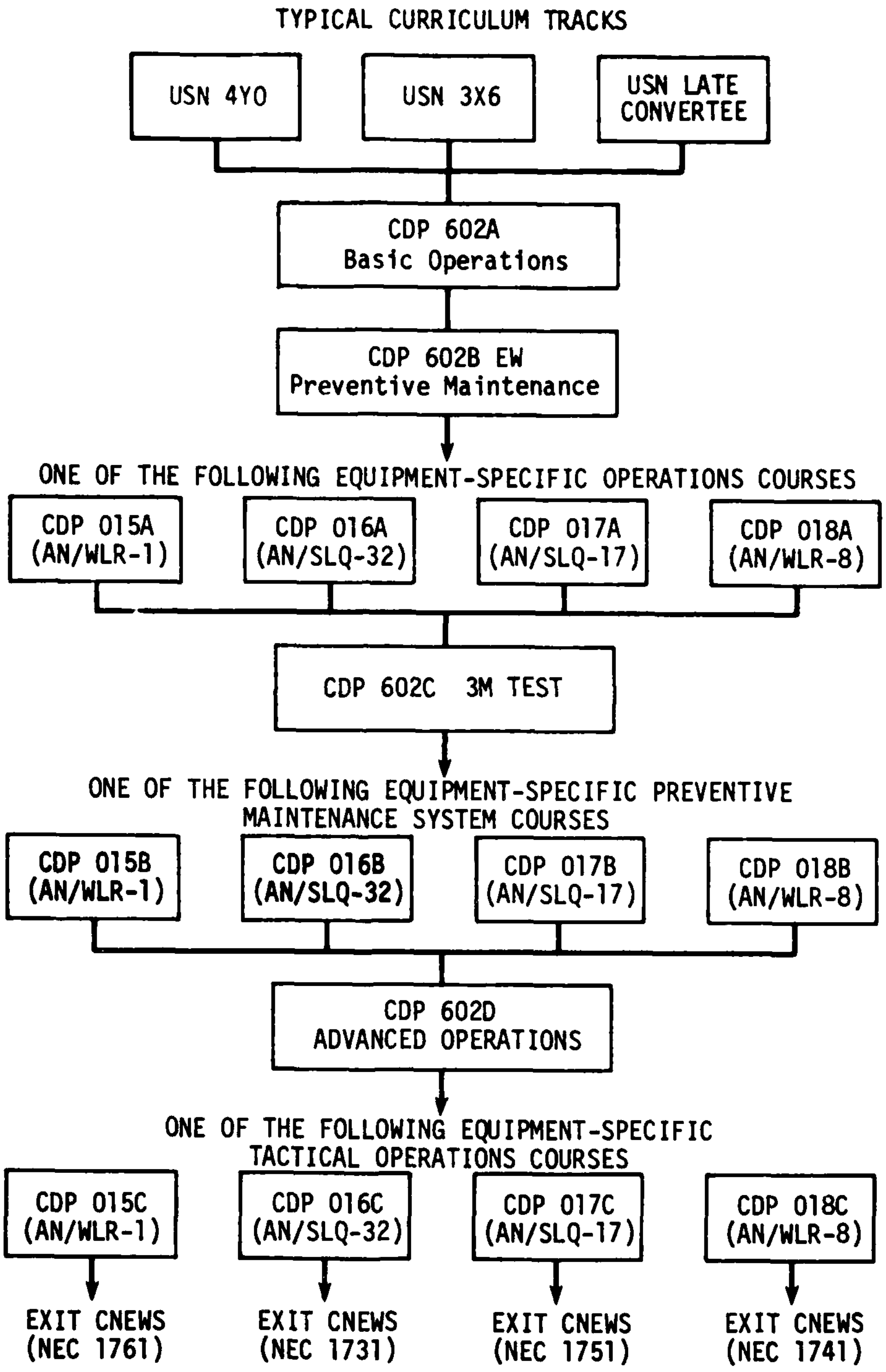


Figure 2. CNEWS General Curriculum Track for Enlisted Students

TABLE 3. CNEWS ENLISTED STUDENT TRACKS

Track Number	Type Student	Equipment Classification	Course Sequence										Weeks Total	NEC Awarded
1	USN 6YO	AN/WLR-1	602A Basic Opns (4)	602B EW PMT (10)	603A EW CMT (5)	603B EW DIG (4)	015A WLR-1 Eqpt Opns (1)	602C 3M Test (2)	015D WLR-1 Maint (11)	412M ULO-6C (4)	602D ADV Opns (3)	015C WLR-1 TACOPS (2)	46	1761
2	USN 6YO	AN/SLQ-32	602A Basic Opns (4)	602B EW PMT (10)	603A EW CMT (5)	603B EW DIG (4)	016A SLQ-32 Eqpt Opns (1)	602C 3M Test (2)	016D SLQ-32 UYK19 (3)	602D Adv Opns (3)	016E SLQ-32 ESM V-1 (6) or 016E SLQ-32 ECM V-2 (3)	016C SLQ-32 TACOPS (2)	40 43	1731(V1) 1731(V2)
3	USN 6YO	AN/SLQ-17	602A Basic Opns (4)	602B EW PMT (10)	603A EW CMT (5)	603B EW DIG (4)	017A SLQ-17 Eqpt Opns (1)	602C 3M Test (2)	017D SLQ-17 UYK-20 (4)	017E SLQ-17 ESM (18)	602D ADV Opns (3)	017C SLQ-17 TACOPS (2)	55	1751
4	USN 6YO	AN/WLR-8	602A Basic Opns (4)	602B EW PMT (10)	603A EW CMT (5)	603B EW DIG (4)	018A WLR-8 Eqpt Opns (1)	602C 3M Test (2)	018D WLR-8 Maint (11)		602D ADV Opns (3)	018C WLR-8 TACOPS (2)	42	1741

TABLE 3. CNEWS ENLISTED STUDENT TRACKS (continued)

Track Number	Type Student	Equipment Classification	Course Sequence							Weeks Total	NEC Awarded
5	USN 4YO	AN/WLR-1	602A Basic Opns (4)	602B EW PMT (10)	015A WLR-1 Eqpt Opns (1)	602C 3M Test (2)	015B WLR-1 PMS (2)	602D ADV Opns (3)	015C WLR-1 TACOPS (2)	22	1761
6	USN 4YO	AN/SLQ-32	602A Basic Opns (4)	602B EW PMT (10)	016A SLQ-32 Eqpt Opns (1)	602C 3M Test (2)	016B SLQ-32 PMS (2)	602D ADV Opns (3)	016C SLQ-32 TACOPS (2)	22	1731
7	USN 4YO	AN/SLQ-17	602A Basic Opns (4)	602B EW PMT (10)	017A SLQ-17 Eqpt Opns (1)	602C 3M Test (2)	017B SLQ-17 PMS (2)	602D ADV Opns (3)	017C SLQ-17 TACOPS (2)	22	1751
8	USN 4YO	AN/WLR-8	602A Basic Opns (4)	602B EW PMT (10)	018A WLR-8 Eqpt Opns (1)	602C 3M Test (2)	018B WLR-8 PMS (2)	602D ADV Opns (3)	018C WLR-8 TACOPS (2)	22	1741

TABLE 3. CNEWS ENLISTED STUDENT TRACKS (continued)

Track Number	Type Student	Equipment Classification	Course Sequence							Weeks Total	NEC Awarded
9	USN 3X6	AN/WLR-1	602A Basic Opns (4)	602B EW PMT (10)	015A WLR-1 Eqpt Opns (1)	602C 3M Test (2)	015B WLR-1 PMS (2)	602D ADV Opns (3)	015C WLR-1 TACOPS (2)	22	1761
10	USN 3X6	AN/SLQ-32	602A Basic Opns (4)	602B EW PMT (10)	016A SLQ-32 Eqpt Opns (1)	602C 3M Test (2)	016B SLQ-32 PMS (2)	602D ADV Opns (3)	016C SLQ-32 TACOPS (2)	22	1731
11	USN 3X6	AN/SLQ-17	602A Basic Opns (4)	602B EW PMT (10)	017A SLQ-17 Eqpt Opns (1)	602C 3M Test (2)	017B SLQ-17 PMS (2)	602D ADV Opns (3)	017C SLQ-17 TACOPS (2)	22	1751
12	USN 3X6	AN/WLR-8	602A Basic Opns (4)	602B EW PMT (10)	018A WLR-8 Eqpt Opns (1)	602C 3M Test (2)	018B WLR-8 PMS (2)	602D ADV Opns (3)	018C WLR-8 TACOPS (2)	22	1741

TABLE 3. CNEWS ENLISTED STUDENT TRACKS (continued)

Track Number	Type Student	Equipment Classification	Course Sequence							Weeks Total	NEC Awarded
13	USN Late Convertee	AN/WLR-1	602A Basic Opns (4)	602B EW PMT (10)	015A WLR-1 Eqpt Opns (1)	602C 3M Test (2)	015B WLR-1 PMS (2)	602D ADV Opns (3)	015C WLR-1 TACOPS (2)	22	1761
14	USN Late Convertee	AN/SLQ-32	602A Basic Opns (4)	602B EW PMT (10)	016A SLQ-32 Eqpt Opns (1)	602C 3M Test (2)	016B SLQ-32 PMS (2)	602D ADV Opns (3)	016C SLQ-32 TACOPS (2)	22	1731
15	USN Late Convertee	AN/SLQ-17	602A Basic Opns (4)	602B EW PMT (10)	017A SLQ-17 Eqpt Opns (1)	602C 3M Test (2)	017B SLQ-17 PMS (2)	602D ADV Opns (3)	017C SLQ-17 TACOPS (2)	22	1751
16	USN Late Convertee	AN/WLR-8	602A Basic Opns (4)	602B EW PMT (10)	018A WLR-8 Eqpt Opns (1)	602C 3M Test (2)	018B WLR-8 PMS (2)	602D ADV Opns (3)	018C WLR-8 TACOPS (2)	22	1741

TABLE 3. CNEWS ENLISTED STUDENT TRACKS (continued)

Track Number	Type Student	Equipment Classification	Course Sequence								Weeks Total	NEC Awarded
17	USN 4X10	AN/WLR-1	602A Basic Opns (4)	602B EW PMT (10)	603A EW CMT (5)	015A WLR-1 Eqpt Opns (2)	602C 3M Test (2)	015D WLR-1 ESM Maint (11)	602D ADV Opns (3)	015C WLR-1 TACOPS (2)	39	1761
18	USN ETSU		604A ETSU PMT (10)	604B ETSU CMT (4)	604C ETSU COMM/ Radar (3)	604D ETSU DIG (4)					21	ETSU
19	USN CTM 6YO		605A CTM PMT (10)	605B CTM CMT (3)	605C CTM DIG (4)						17	
20	U.S. Coast Guard	AN/WLR-1	015D WLR-1 ESM Maint (11)								11	
21	USN CTM		605C CTM Tech-nology (4)	412M AN/ULQ-6 Maint (4)							8	

TABLE 3. CNEWS ENLISTED STUDENT TRACKS (continued)

Track Number	Type Student	Equipment Classification	Course Sequence				Weeks Total	NEC Awarded
22	Fleet Returnee - Operator & Maintainer	AN/WLR-8	603B EW DIG (4)	018B WLR-8 Maint (11)	018C WLR-8 TACOPS (2)		15	1741
23	Fleet Returnee - Operator & Maintainer	AN/SLQ-17	603B EW DIG (4)	017D SLQ-17 UYK-20 (4)	017E SLQ-17 ESM (18)	017C SLQ-17 TACOPS (2)	28	1751
24	Fleet Returnee - Operator & Maintainer	AN/SLQ-32	603B EW DIG (4)	016D SLQ-32 UYK19 (3)	016E SLQ-32 ESM V-1 (6) or 016E SLQ-32 ECM V-2 (3)	016C SLQ-32 TACOPS (2)	15(V1) 12(V2)	1731(V1) 1731(V2)
25	Fleet Returnee - Operator & Maintainer	Digital	603B EW DIG (4)				4	
26	Fleet Returnee - Operator & Maintainer	AN/ULQ-6C	603B EW DIG (4)	412M ULQ-6C (4)			8	

TABLE 3. CNEWS ENLISTED STUDENT TRACKS (continued)

Track Number	Type Student	Equipment Classification	Course Sequence			Weeks Total	NEC Awarded
27	Fleet Returnee - Operator Only	AN/SLQ-32	016A SLQ-32 Eqpt Opns (1)	016B SLQ-32 PMS (2)	016C SLQ-32 TACOPS (2)	5	1731
28	Fleet Returnee - Operator Only	AN/SLQ-17	017A SLQ-17 Eqpt Opns (1)	017B SLQ-17 PMS (2)	017C SLQ-17 TACOPS (2)	5	1751
29	Fleet Returnee - Operator Only	AN/WLR-8	018A WLR-8 Eqpt Opns (1)	018B WLR-8 PMS (2)	018C WLR-8 TACOPS (2)	5	1741

TABLE 4. CNEWS STUDENT INPUT FORECAST (OFFICER AND ENLISTED)

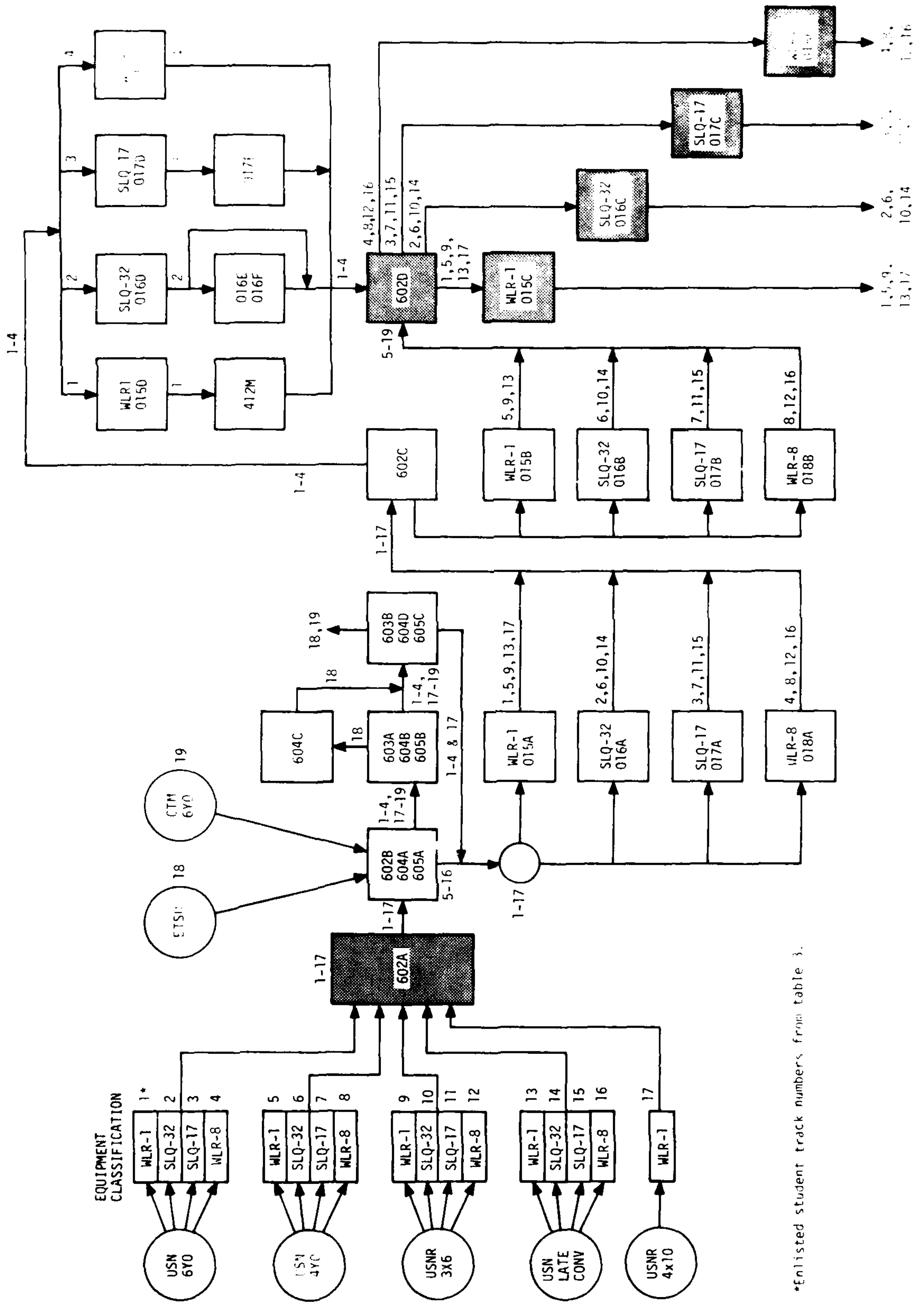
OFFICER

Track No.	Officer Category	Weeks	Student Input Forecast (FY) 80	81	82	83	84
6474	VQ - Pilot Navigator PIREP (EA6)	5	30	30	30	30	30
6475	Aviation EW Officer (ASW/TACAIR)	3	64	64	64	64	64
9795	EA-6B Fleet Replacement Pilot	5	30	30	30	30	30
9797	Fleet Air Reconnaissance EW Evaluator (VQ)	18	34	34	34	34	34
9798	EA6B Fleet Replacement NFO ECMO	18	43	43	43	43	43
9799	VAQ-33 NFO Fleet EW	18	8	8	8	8	8
9928	EA6 USMC Aviation EW	18	16	16	16	16	16

ENLISTED

Track No.	Student Category	Equipment Track	Student Input Forecast (FY) 80	81	82	83	84
1	USN 6 YO	AN/WLR-1	158	135	161	154	160
2	USN 6 YO	AN/SLQ-32	53	73	96	101	87
3	USN 6 YO	AN/SLQ-17	6	5	7	9	11
4	USN 6 YO	AN/WLR-8	0	4	6	6	12
5	USN 4 YO	AN/WLR-1	162	162	200	225	225*
6	USN 4 YO	AN/SLQ-32					
7	USN 4 YO	AN/SLQ-17					
8	USN 4 YO	AN/WLR-8					
9	USN 3x6	AN/WLR-1	19	40	40	40	40*
10	USN 3x6	AN/SLQ-32					
11	USN 3x6	AN/SLQ-17					
12	USN 3x6	AN/WLR-8					
13	USN Late Convertee	AN/WLR-1	Data not available for category				
14	USN Late Convertee	AN/SLQ-32					
15	USN Late Convertee	AN/SLQ-17					
16	USN Late Convertee	AN/WLR-8					
17	USNR 4x10	AN/WLR-1	25	20	20	20	20
18	USN ETSU		86	86	86	86	86
19	USN CTM 6 YO		412	413	410	384	335
20	US Coast Guard	AN/WLR-1	24	24	24	24	24
21	USN CTM (Crypto)		60	60	60	60	60
22	Fleet Returnee, Operator & Maintainer	AN/WLR-8	Data not available for category				
23	Fleet Returnee, Operator & Maintainer	AN/SLQ-17					
24	Fleet Returnee, Operator & Maintainer	AN/SLQ-32					
25	Fleet Returnee, Operator & Maintainer	Digital	Data not available for category				
26	Fleet Returnee, Operator & Maintainer	AN/ULQ 6 C	79	56	36	28	22
27	Fleet Returnee, Operator only	AN/SLQ-32	15	15	29	28	21
28	Fleet Returnee, Operator only	AN/SLQ-17	1	2	1	2	4
29	Fleet Returnee, Operator only	AN/WLR-8	Data not available for category				

*Student input data by equipment track not available; i.e., aggregate data for student category.



*Enlisted student track numbers from table 3.

Figure 3. CNEWS Student Flow by Tracks and Courses (Part A)

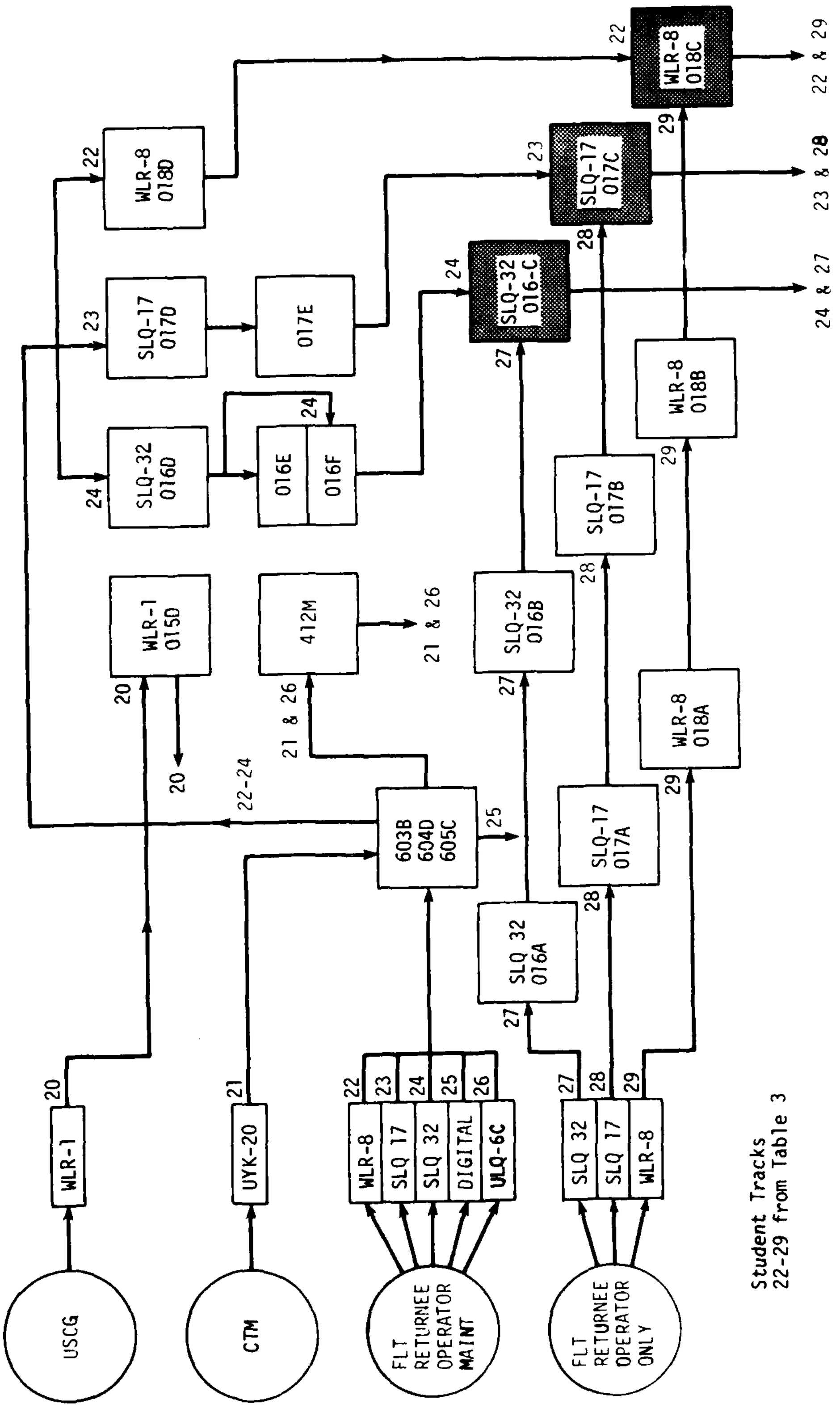


Figure 3. CNEWS Student Flow by Tracks and Courses (Part B)

The facility resources are a key element in the CNEWS data base since these fixed resources will determine/impact a number of variables used in the model. These data were collected for the CNEWS classrooms and training facilities/equipment currently used to conduct each course. Table 5 is a data matrix which identifies those CNEWS classrooms and facilities that are used by more than one course. Facilities are identified in terms of learning centers, classrooms, and laboratories with classroom building or administrative building number and courses (by CDP number) which use the facilities. The data will be incorporated in the model as a means of describing the processing of students through their curriculum tracks in order to identify resource utilization patterns.

CONSOLIDATED EW OPERATOR CURRICULUM DEVELOPMENT

The EW operator curriculum under development for implementation with Device 10H1 will be individualized (self-paced) instruction. The major difference between the present group-paced (lock-step) operator curriculum and the individualized curriculum under development for Device 10H1 is student self-pacing through each curriculum module, lesson, and lesson topic. Each lesson topic is completed by the student in either a classroom, a learning center with multimedia learning carrels, or a laboratory using one of the student stations of Device 10H1. The learning carrels consist of individual study booths equipped with various combinations of sound/slide equipment and/or random-access, interactive video tape equipment. The student is appropriately supported with lesson topic narratives and/or programmed materials or other types of individualized learning materials. Device 10H1 is a multi-station training device in which generalized functional capabilities of present and projected future EW equipments are represented. These are described in appendix A.

The individualized EW operator curriculum under development for implementation with Device 10H1 consists of three curriculum phases:

Phase I	Basic Operations
Phase II	Advanced Operations
Phase III	Watchstanding and Tactical Operations Exercises.

Figure 4 shows the projected flow for all categories of students through the CNEWS three-phase curriculum using the learning centers (LC) and curriculum phases for Device 10H1. Enlisted EW students take phase I, then take selected maintenance, technology, and equipment-specific maintenance courses, followed by appropriate phase II and III courses using Device 10H1 according to their duty assignment and the type of EW operational equipment they will operate and maintain at their duty station.

Officer students will take phase I of the Device 10H1 operator curriculum, followed by appropriate modules, lessons, and lesson topics in phases II and III of the curriculum developed for use with Device 10H1 as appropriate for the equipment they will operate at their next duty assignment.

Figure 3, presented in the earlier discussion of the current CNEWS curriculum, shows the major enlisted student tracks through CNEWS and identifies

the courses each student takes and the sequence in which the courses are taken. The shaded course boxes in figure 3 show where in the curriculum Device 10H1 operator courses will replace existing courses.

In order to adequately describe (for simulation purposes) individual student flows through the Device 10H1 curriculum under development, it was necessary to collect data on individualized lesson topics within the modules of each of the three phases of the Device 10H1 operations curriculum that will replace the existing operations courses. Figure 5 shows the typical student path through phases of the Device 10H1 operations curriculum. In phase I (basic operations) of the Device 10H1 curriculum under development, students will complete a series of academic or off-line (non-10H1) modules in learning centers and then receive a series of modules and lesson topics using Device 10H1 to complete that portion of the curriculum. The basic operations phase of the individualized curriculum using Device 10H1 is planned to be common-core; i.e., each category of student, officer and enlisted, will take the phase I courses. Table 6 shows the proposed learning center and Device 10H1 student hour distribution for the three phases of the individualized curriculum using Device 10H1.

Phase II (advanced operations) of the Device 10H1 curriculum will consist of a series of six modules with a number of lesson topics. The number of hours each student is estimated to spend in phase II in the learning centers and Device 10H1 is shown in table 6. Unlike the phase I student traffic flow in which the student completes a series of off-line academic modules and then completes a series of modules using Device 10H1, the student's path through phase II will consist of a series of sessions in the learning center for each module, followed by a number of hours of training on Device 10H1 in the next module. As a student completes each module in Device 10H1, he will then proceed to the next assigned module taking a series of lesson topics in the learning center, followed by an appropriate number of hours or lesson topics in Device 10H1 until that module is complete. Students take only assigned modules in phase II according to their duty assignments; i.e., each student does not take each module in phase II.

When the student reaches phase III (watchstanding and tactical operations) in Device 10H1, his training will become equipment-oriented and will consist of two parts as shown in table 6. Part A of phase III consists of a series of exercises to orient the student to the type of equipment he will operate in his duty assignment. Part B of phase III consists of a series of exercises or lesson topics in the form of mission scenarios using the equipment suite he used in part A of phase III. Student flow through phase III will consist of a series of hours of training in Device 10H1 in parts A and B on the respective EW equipment modules and lesson topics appropriate for his military specialty and/or next duty assignment.

DESIGN GOALS FOR THE SIMULATION MODEL OF CNEWS

A design goal of the study is to develop a simulation model of the student flows through the CNEWS operator curriculum using Device 10H1. Based on the likelihood of the Device 10H1 curriculum being incrementally implemented

TABLE 5. CROSS UTILIZATION OF TRAINING FACILITIES

Building	FACILITY \ CDP	ENLISTED														
		602A	C1	015A	016A	017A	018A	602C	015B	016B	017B	018B	C2	C3	015D	016D
	LC 102	X														
	LAB 134	X		X												
	LAB 135	X		X												
	CR 113															
	LC 114	X														
	CR 115														X	
	CR 116								X							
	CR 117									X						
	LAB 239															
	LAB 139				X											
	CR 140				X											
	CR 141															
	CR 142															
	CR 143															
	CR 122												X			
	CR 123												X			
	CR 124												X			
	CR 125	X	X													
	LAB 145															
	LAB 146															
	CR 148	X	X													
	CR 149	X	X													
	CR 150	X	X													
	CR 151	X	X													
	LAB 153															
	CR 154	X	X													
	CR 155															
	LAB 237	X	X										X			
	LAB 238	X	X										X			
CLASSROOM BUILDING	LAB/CR 210A					X	X				X	X				
	LAB/CR 206A															
	CR 202													X		
	LAB 203													X		
	CR 204													X		
	LAB 229															
	LAB/CR 230														X	
	LAB 231														X	
	LAB 213														X	
	LAB 214														X	
	CR/LAB 215							X								
	CR/LAB 232															
	CR 203A															
	CR 234														X	
	CR/LAB 235															
	LAB 219A															
	CR 220A															
	LAB 221A									X						
	CR/LAB 216														X	
	CR 217															
	LAB 218							X								
	CR/LAB 240															
	CR 228A															
	CR 227A															X
	LAB 230A									X						X
	CR 227														X	
	CR/LAB 228															
	CR/LAB 242															
	CR 243									X						
	CR 244									X						
	CR 204A															
	LAB 205A															
	LAB 211A															
ADMINISTRATION BUILDING	CR 126															
	CR 127															
	CR 208															
	CR 211															
	CR 212															
	CR 213															

FACILITY \ CDP	ENLISTED													OFFICER	
	017D	018D	412M	016E	017E	016F	604C	602D	015C	016C	017C	018C	3197	3512	6474
LC 102															
LAB 134								X							
LAB 135								X							
CR 113							X								
LC 114															
CR 115				X											
CR 116															
CR 117															
LAB 239															
LAB 139										X					
CR 140										X					
CR 141								X							
CR 142								X							
CR 143									X	X					
CR 122															
CR 123															
CR 124															
CR 125															
LAB 145									X						
LAB 146															X
CR 148															
CR 149															
CR 150															
CR 151															
LAB 153													X		
CR 154															
CR 155													X		
LAB 237															
LAB 238															
LAB/CR 210A		X			X						X	X			
LAB/CR 206A															
CR 202															
LAB 203															
CR 204															
LAB 229															
LAB/CR 230															
LAB 231															
LAB 213															
LAB 214															
CR/LAB 215															
CR/LAB 232	X														
CR 203A															
CR 234															
CR/LAB 235			X												
LAB 219A															
CR 220A				X											
LAB 221A						X									
CR/LAB 216															
CR 217			X												
LAB 218															
CR/LAB 240			X												
CR 228A															
CR 227A															
LAB 230A				X		X									
CR 227															
CR/LAB 228															
CR/LAB 242															
CR 243															
CR 244															
CR 204A															
LAB 205A															
LAB 211A															
CR 126														X	
CR 127														X	
CR 208															
CR 211															
CR 212															X
CR 213															

FACILITY \ CDP	OFFICER						[illegible]								
	6475	9795	9797	9798	9799	9928	4125	412X	4710	4263	020A	023M	4354	431A	544G
LC 102															
LAB 134															
LAB 135															
CR 113															
LC 114															
CR 115															
CR 116															
CR 117															
LAB 239														X	
LAB 139															
CR 140															
CR 141															
CR 142															
CR 143															
CR 122															
CR 123															
CR 124															
CR 125															
LAB 145															
LAB 146	X	X	X	X	X	X									
CR 148															
CR 149															
CR 150															
CR 151															
LAB 153															
CR 154															
CR 155															
LAB 237															
LAB 238															
LAB/CR 210A												X			
LAB/CR 206A													X		
CR 202															
LAB 203															
CR 204															
LAB 229															
LAB/CR 230															
LAB 231															
LAB 213															
LAB 214															
CR/LAB 215															
CR/LAB 232											X				
CR 203A													X		
CR 234															
CR/LAB 235															
LAB 219A									X						
CR 220A															
LAB 221A															
CR/LAB 216															
CR 217															
LAB 218															
CR/LAB 240															
CR 228A															
CR 227A									X	X					
LAB 230A															
CR 227															
CR/LAB 228															
CR/LAB 242							X	X							
CR 243															X
CR 244															
CR 204A														X	
LAB 205A														X	
LAB 211A														X	
CR 126															
CR 127															
CR 208															
CR 211		X	X	X	X	X									
CR 212		X	X	X	X	X									
CR 213	X														

LR - Learning Center
CR - Classroom
LAB - Laboratory
CR/LAB - Classroom/Lab

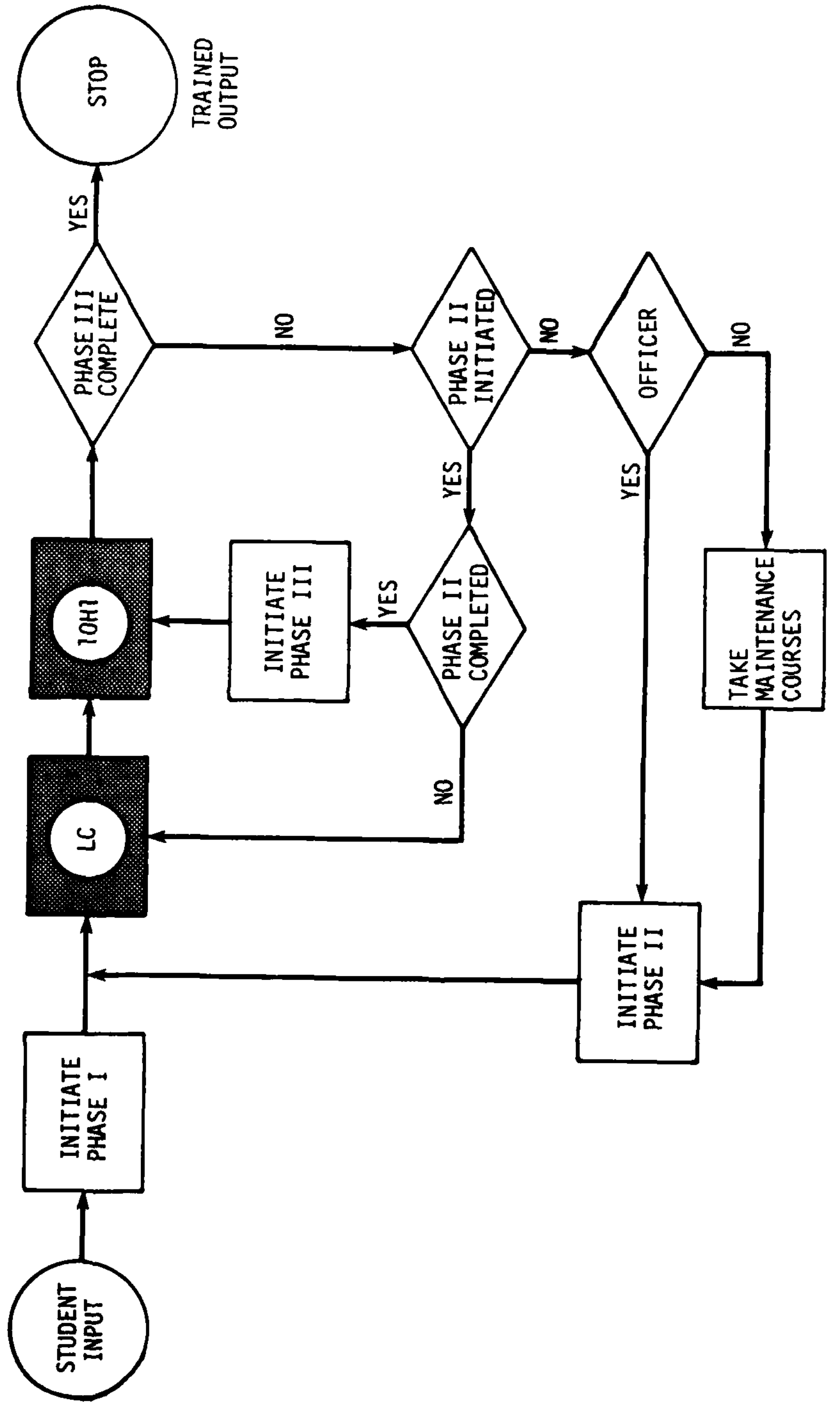


Figure 4. Proposed Macro EW Training Model With Device 10H1 Curriculum Phases

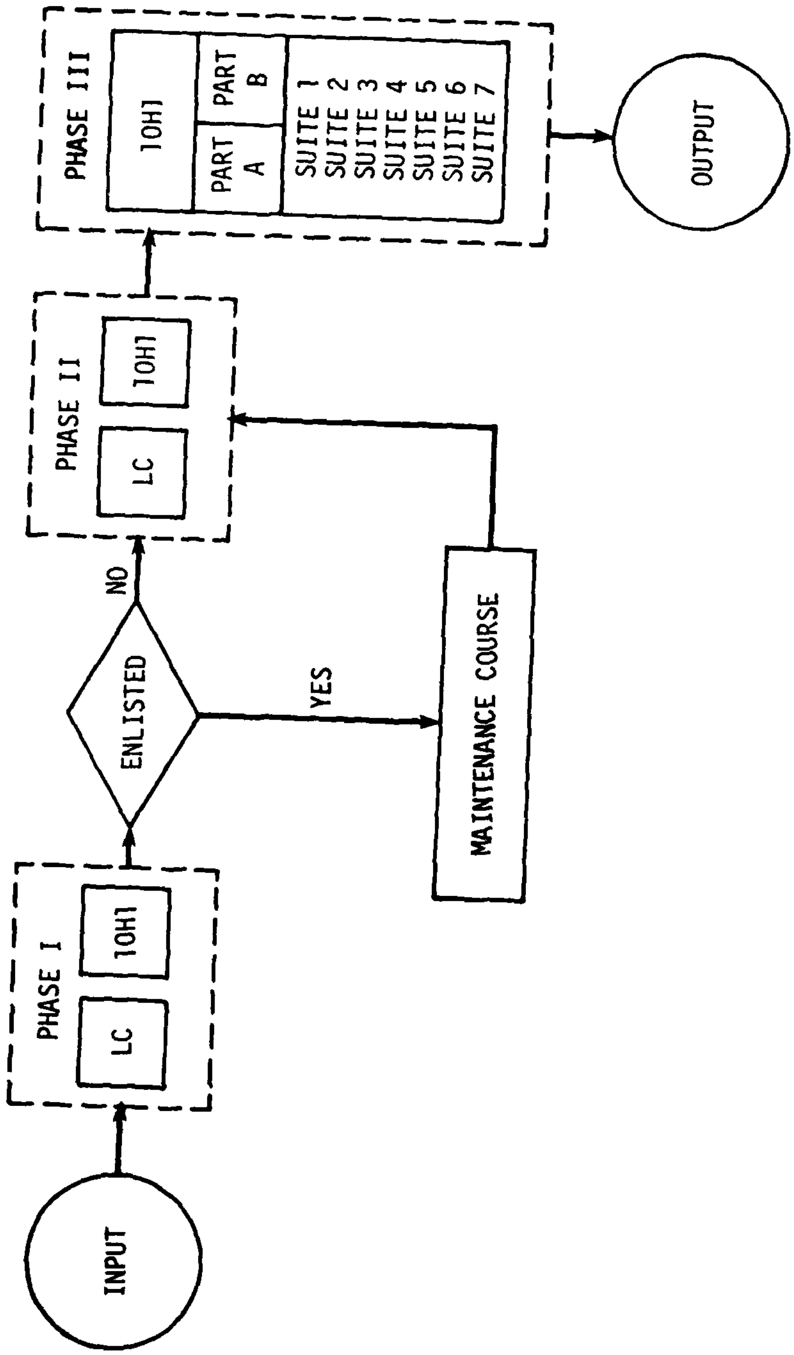


Figure 5. *Consolidated EW Operator Training Student Flow with Device 10H1*

TABLE 6. ESTIMATED STUDENT FLOWS THROUGH PHASES I, II, AND III OF OPERATOR CURRICULUM USING DEVICE 10H1

ESTIMATED TIMES-TO-TRAIN (INDIVIDUALIZED INSTRUCTION)

Phase I
Basic Operations

Module Number	Classroom/ Learning Center (hours)	Device 10H1 (hours)
1	5	
2	3	
3	6	
4	1	
5	3	22
6	6	29
7	1	3
8	11	
9	5	
10	4	
11	5	

Phase II
Advanced Operations

Module Number	Classroom/ Learning Center	Device 10H1
15	18	23
16	5	5
17	24	54
18	10	11
19 & 20 (combined)	14	9
21	10	36

Phase III Part A Watchstanding Exercises		Phase III Part B Tactical Operations Exercises	
Module Number	Device 10H1	Module Number	Device 10H1
22	34	39	99
23	36	40	48
24	16	41	9
25	19	42	66
26	42	43, 44, 45 & 46 (combined)	66
27,28 & 29 (combined)	24		

within CNEWS, it was decided to develop the model in eight increments in order to be able to determine the impacts of incrementally implementing the three phases of the Device 10H1 curriculum. The model will be developed in the following increments:

- CNEWS Current Operator and Maintenance Curriculum (No Device 10H1)
- CNEWS Current Curriculum With Device 10H1 Phase I (Basic Operations) Implemented and Replacing Existing Basic Operations Course
- CNEWS Current Curriculum With Device 10H1 Phase II (Advanced Operations) Implemented and Replacing Existing Advanced Operations Courses
- CNEWS Current Curriculum With Device 10H1 Phase III (Watchstanding-Tactical Operations) Implemented and Replacing Existing Tactical Operations Courses
- CNEWS Current Curriculum With Device 10H1 Phases I and II Implemented and Replacing Existing Basic and Advanced Operations Courses
- CNEWS Current Curriculum with Device 10H1 Phases I and III Implemented and Replacing Existing Basic and Tactical Operations Courses
- CNEWS Current Curriculum With Device 10H1 Phases II and III Implemented and replacing Existing Advanced Operations and Tactical Operations courses
- CNEWS Current Curriculum with Device 10H1 Phases I, II and III Implemented and Replacing Existing Basic, Advanced, and Tactical Operations Courses.

As a result of meetings held among personnel from CNEWS, the CNTECHTRA Training Program Coordinator, and the CNTECHTRA CMI System Manager, additional design goals were developed and agreed to for the student flow simulation model. These design goals, which are summarized in table 7, provided guidance for subsequent detailed data collection efforts during the remainder of phase I of the study.

The overriding consideration in the development of the model is that it provide CNEWS with a decision-aiding tool in accomplishing their mission of supporting the Navy's EW training program and in the development of the consolidated EW operator curriculum using Device 10H1.

The next section presents an overview of the method of study for modeling the student flows as well as a discussion of the rationale for selecting the simulation approach for use as a forecasting tool.

TABLE 7. EW STUDENT FLOW SIMULATION DESIGN GOAL SUMMARY

1. Be able to structure and prioritize course convening frequencies as a function of competition for training resources.

2. Identify potential conflicts of resource demands and define feasible alternatives in time to avoid them.

3. Smooth the flow of students between self-paced and lock-step courses within the curriculum.

4. Provide a means of planning dual pipelines; i.e., existing curriculum and the EW operator curriculum using Device 10H1, in terms of cross utilization of resources against the old/new curricula.

5. The output of the model should be compatible in feeding other data processing systems such as Military Personnel System, NITRAS, CMI, and Shorestamps.

6. Be able to compare existing school course capacity against planned requirements in terms of:

   a. Number and types of students
   b. Convening frequency
   c. Course sequencing
   d. Instruction/staff loading
   e. Instructional materials, media, devices, equipment
   f. Facilities.

7. Provide a forecast of recommended alternative school decrements as a function of its variables, identifying the extent of the effects of each variable on others, and in terms of feasible changes that will allow solution in terms of how school operates.

8. Differentiate the critical factors within the model needed to describe course training activities and significant peripheral factors such as administrative constraints that are useful but not critical and could be used to identify alternative solutions and optional factors within the model such as reporting data which are not essential to making the model run but which can provide valuable outputs in formats for use by school.

9. Be compatible for use with the Navy's CMI computer facilities via the CMI on-site facilities at the school.

10. Provide graphical or other type representations of the model's output for user's decision-aiding; e.g., current or projected resource utilization versus planned or capacity over time on basis of each training day as students progress through pipeline.

11. Have authoring and user programs compatible with the EW school's personnel capabilities.

SECTION III

SIMULATION MODEL SELECTION

This section presents an overview of the method selected for modeling the CNEWS student flow. The rationale for adopting the selected simulation approach for use as a forecasting tool is also described.

CHOICE OF THE TYPE OF MODEL

In general, mathematical models can be classified into static or dynamic models, depending upon how the time element in the model is treated. Static models can only show the values that system attributes take when the system is in balance, while dynamic models follow the changes over time that result from the system activities. Under each of these classifications, a distinction is made between analytical and numerical models, depending upon the technique by which the model is solved. Analytical methods involve applying the deductive reasoning of mathematical theory to solve a model. Numerical methods, on the other hand, apply computational procedures to solve a model. Finally, another distinction by which models are often classified is whether they are deterministic or stochastic (or probabilistic). Deterministic models contain no random processes in the system, while stochastic models have random processes in their system. The classifications described above are summarized in figure 6.

The paradigm considered to be appropriate for a simulation of CNEWS student flows is a dynamic, numerical computation model encompassing stochastic variables. The CNEWS curriculum and student flow problems are dynamic in that they must explicitly acknowledge the passage of time. The introduction of self-paced instructional systems introduces a stochastic variable in terms of student's completion time of the courses.

The desired outputs of the simulation are described in section IV.

SIMULATION MODEL BUILDING PROCESS

Successful problem formulation is a critical step in developing a simulation model for the CNEWS student flows. The initial step in problem formulation is to specify the objectives or purposes to be achieved by the model. Objectives must be defined in operational (quantitative) terms that can be directly related to the performance measurements that are to be made within the simulation model. The conflict which might arise from the simultaneous achievement of multiple objectives in the model has to be resolved by establishing the specific levels of detail and the boundaries of the student flows that will be simulated within given time periods and the resources that will be involved.

Figure 7 is a conceptual view of the model building approach used for this study. The details of the desired performance measures and design alternatives selected for the CNEWS student flow simulation model are discussed in section IV.

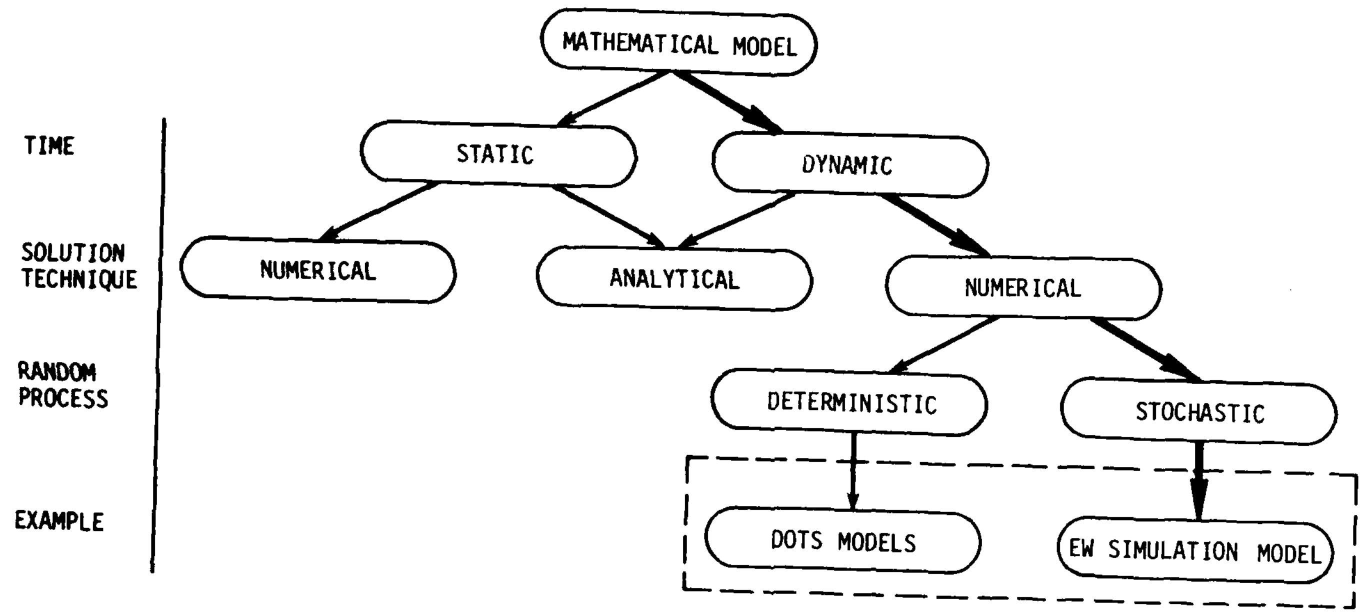


Figure 6. Types of Mathematical Models

*CNET Design of Training System (DOTS) project

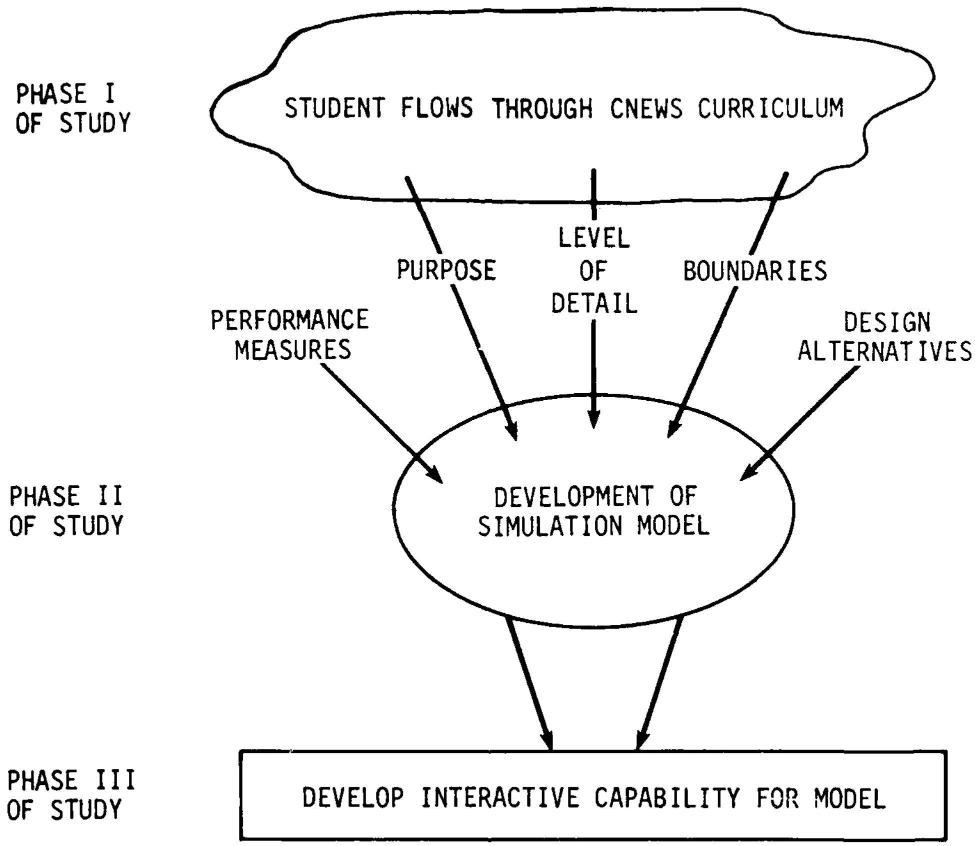


Figure 7. CNEWS Student Flow Simulation Model Building Processes

SELECTION OF A DISCRETE SIMULATION LANGUAGE

After the specific model-building process was defined and the structure of the problem specified, the next step was to select an appropriate simulation language with which to model the decision problem.

TYPES OF SIMULATION LANGUAGE. The widespread use of simulation as an analysis tool has led to the development of a number of languages specifically designed for simulation. These languages are based upon the logical concepts and related language statements required to represent the system being modeled and its state-to-state transitions. Simulation languages can be classified into three categories: (1) process-oriented, (2) event-oriented, and (3) continuous. The major simulation languages currently in use fall within one or more of the categories as shown in figure 8.

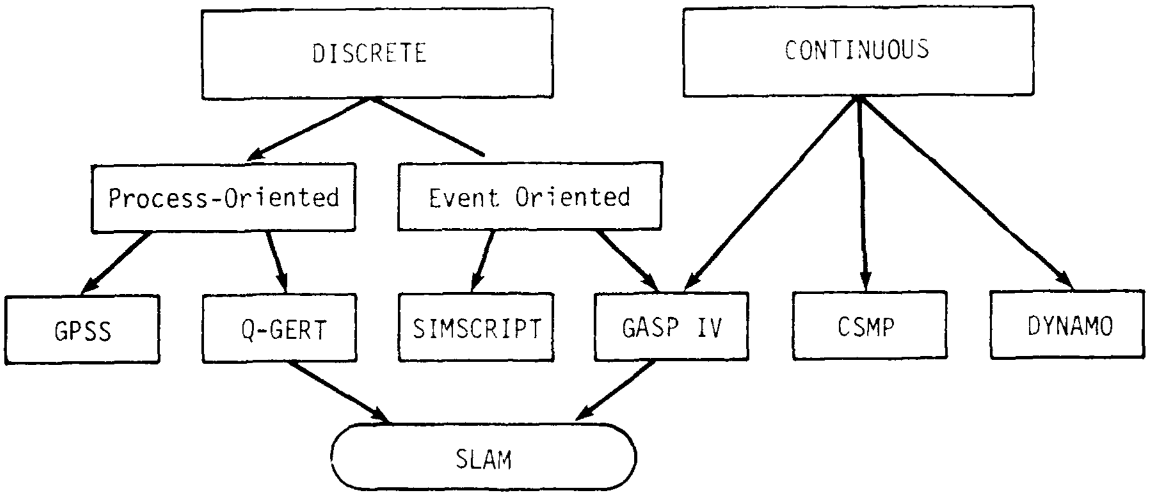


Figure 8. Types of Simulation Language

A brief description of languages falling in these categories is provided in appendix B. Both the General Purpose System Simulation (GPSS) and Queue-Graphic Evaluation and Review Technique (Q-GERT) are process-oriented simulation languages, while SIMSCRIPT is an event-oriented language. Continuous System Modeling Program (CSMP) and Dynamic Modeling (DYNAMO) are widely used continuous process simulation languages. The General Activity Simulation Program (GASP IV) language has been developed to handle both event-oriented and continuous-process type modeling situations.

The simulation language selected for this study is the Simulation Language Alternative Method (SLAM) developed by Pritsker & Associates, Incorporated, Lafayette, Indiana.[1] SLAM was selected based upon its capabilities for both discrete and continuous system modeling and its ability to handle both process- and event-oriented processes. Figure 9 illustrates a comparison of SLAM to other simulation languages in terms of their general applications ability.

Functional Characteristics of Slam. The major functional feature of SLAM is that it allows a system to be modeled from a process-oriented, event-oriented, and/or continuous standpoint. It combines these capabilities within a single unified systems modeling framework. With SLAM, a discrete system can be modeled within an event-orientation or a process-orientation, or from both viewpoints. Continuous systems can be modeled using either differential or difference equations. Combined discrete and continuous systems can be modeled in SLAM by combining the event- and/or process-orientations with the continuous-orientation.

The process-orientation of the SLAM simulation language employs a network structure comprising specialized symbols called nodes and branches in a manner similar to the Q-GERT language. These specialized symbols model various elements in a process such as queues, servers, and decision points. The modeling task consists of combining these symbols into a network model which pictorially represents the system of interest. The pictorial representation of the system is transcribed by the modeler into an equivalent statement for input to the SLAM processor. A hypothetical example of such modeling is described in appendix C.

In the CNEWS student flow modeling problem the process-orientation of SLAM is most important since the current curriculum and the new curriculum under development represent a number of categories of individual students flowing through courses and their separate pipelines or tracks. The objective of the model is to account for each different type of student in the various pipelines, whether they be in group-paced or individualized training courses, and gather statistical data on each student in order to determine resource utilization patterns and to identify likely problem areas such as student queues.

[1]A. Alan Pritsker and Claude Dennis Pegden. Introduction to Simulation and SLAM. N.Y.: John Wiley and Sons, 1979.

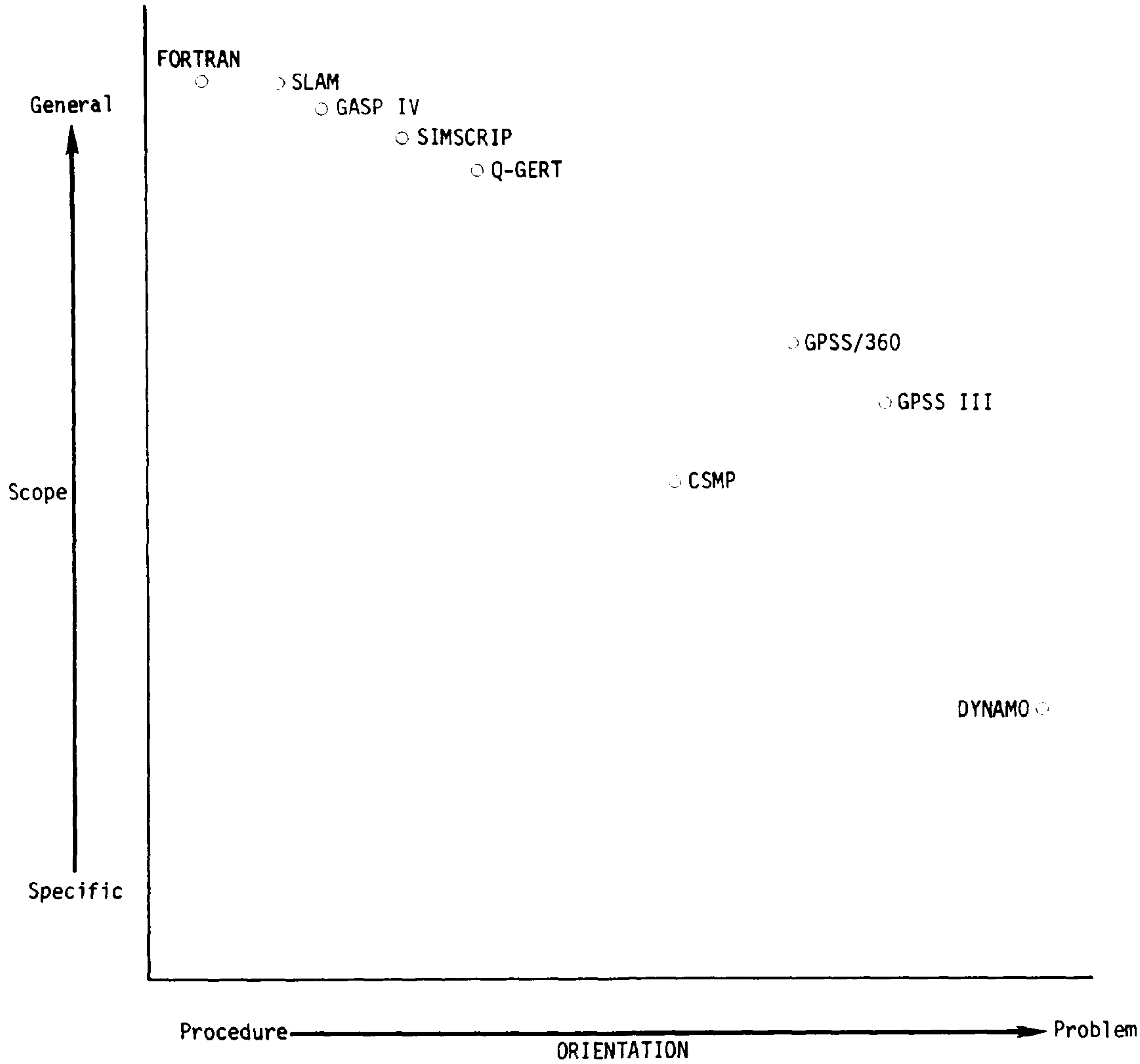


Figure 9. Classification of Simulation Languages According to Their Generality of Application

Figure 9. Classification of Simulation Languages According to Their Generality of Application

SECTION IV

MODEL FEATURES/DEVELOPMENT AND EVALUATION PLAN

This section describes the structure of the EW student flow simulation model, its outputs, and operational characteristics. Also included in this section is the development and evaluation plan for the model.

MODEL STRUCTURE

The model, when fully developed, will be an interactive system in which an operator can perform a variety of functions with a minimal knowledge of computers and models. It will include a number of aids to the user in the form of messages and instructions appearing on the CRT screen. It will also be:

- user-oriented and modular in design to provide flexibility and ease in operation and file manipulation
- programmed in FORTRAN and compatible with the Navy's CMI facilities at Memphis and remote, on-site CMI facilities at CNEWS and other Navy schools
- interactive in its mode of operation with simulation output data to be presented by CRT displays or hard copy printout for management review.

The model will be designed to produce the following types of output over the period of the model run:

- Number of students graduated per course

  Average number of students per class
  Standard deviation of number of students per class
  Coefficient of variation of number of students per class
  Minimum number of students in a class
  Maximum number of students in a class
  Number of classes for each type of course
  Completion time for each type of student per course
  Total number of students who dropped from course

- Course waiting times

  Average number of students at each facility
  Standard deviation of student waiting time at each facility
  Maximum length of waiting time for student for each facility
  Number of students currently in each course

- Course utilization

  Number of students completing a course
  Number of students waiting for a course to convene

Average number of students taking a course
Maximum number of students taking a course
Number of students currently in each course

- Resource activity by type of facility (learning center, Device 10H1, etc.)

  Current capacity or number of facilities available
  Average utilization of each type of facility
  Standard deviation of utilization of each type of facility
  Maximum number of units of each type facility in use at any one time
  Current number of units of each type facility being utilized

- Histograms

  Type of student, by the number per class for each course
  Time distribution to complete curriculum by each type of student
  Total number of each type of student who completes curriculum

As a result of the manpower and time/resource constraints on the present study, a number of potential capabilities for the model were not considered and will not be included in the initial model being developed. The initial model will not be designed to solve optimal class scheduling problems. The capability of the model could be extended to address this class of problem in the future by modifying it to generate input data through simulation which could be incorporated into appropriate mathematical scheduling routines. The initial model will not have the capability to determine optimal sequences of courses to be taken by each type of student. The user will not have the flexibility to alter the sequence of courses to be taken by the students. Whenever any alterations in course sequence are required, appropriate modifications of the model will be required.

Figure 10 depicts the components of the SLAM model. The model inputs consist of scenarios based upon system characteristics of the EW school (i.e., types and categories of students, various curriculum path courses taken by students, and resource utilization patterns). The model outputs include forecast of the number of students of each type graduated per time period (1 to 5 years), training resource demand and utilization patterns, student times-to-train, and queuing times. Each of these outputs is formatted in report style and will provide management personnel information of potential resource conflicts and serve as a data base for projecting future requirements.

Figure 11 provides a general overview of the model's operation. Utilization of the model requires the development of a course data base which must be created prior to model operation. The course data base module consists of the five submodules: (1) 10H1 Status Profile, (2) Instructor Profile, (3) Facility Profile, (4) Course Description Profile, and (5) Input Student Population Profile. The course data base module has a built-in data manipulation function which directs the user to access the five submodules. The data manipulation function can be used either to look up course data elements which are already created or to change any data elements for a course or other simulation parameters. The specific data elements in each submodule are detailed in the following paragraphs.

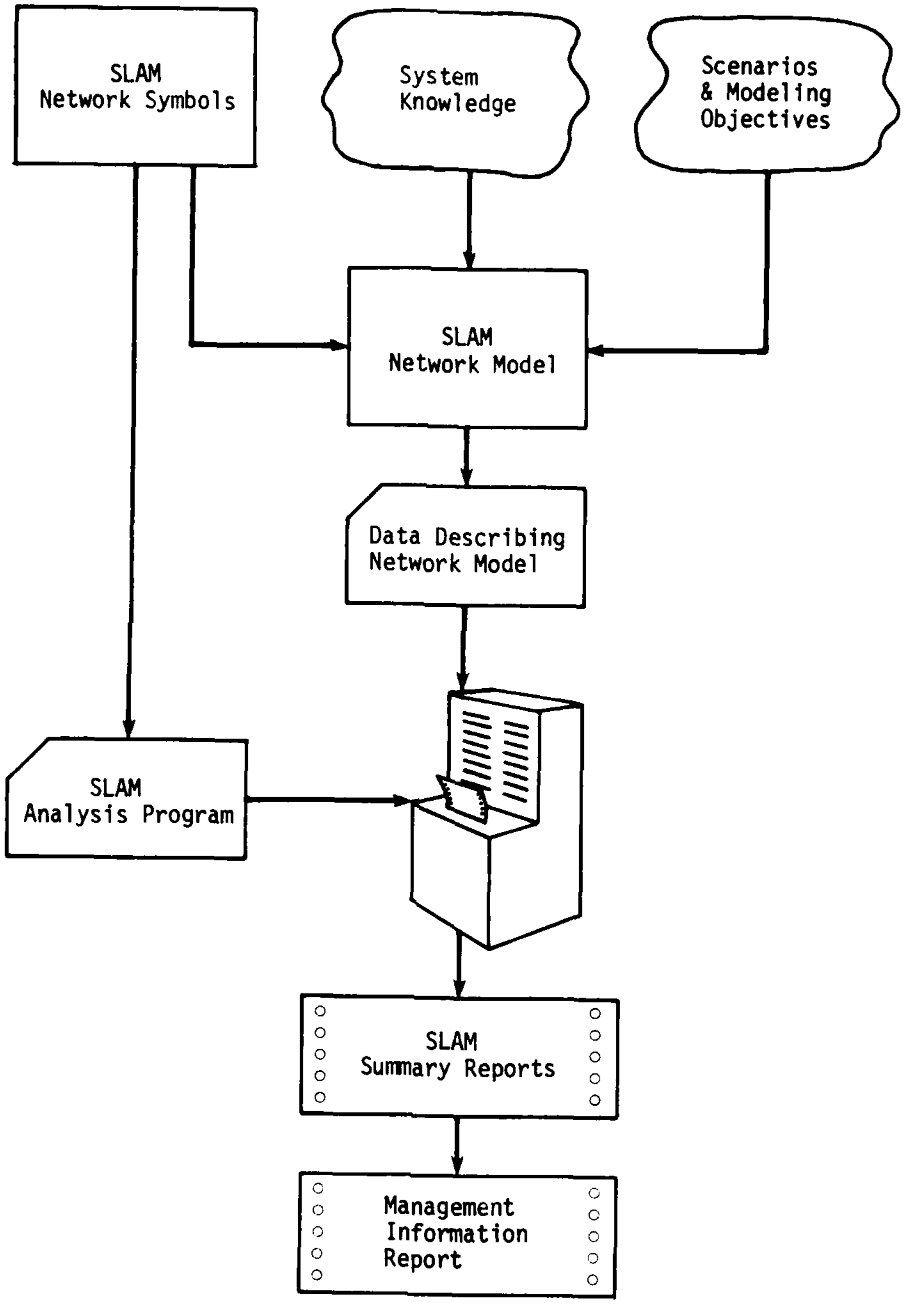


Figure 10. Components of SLAM Model

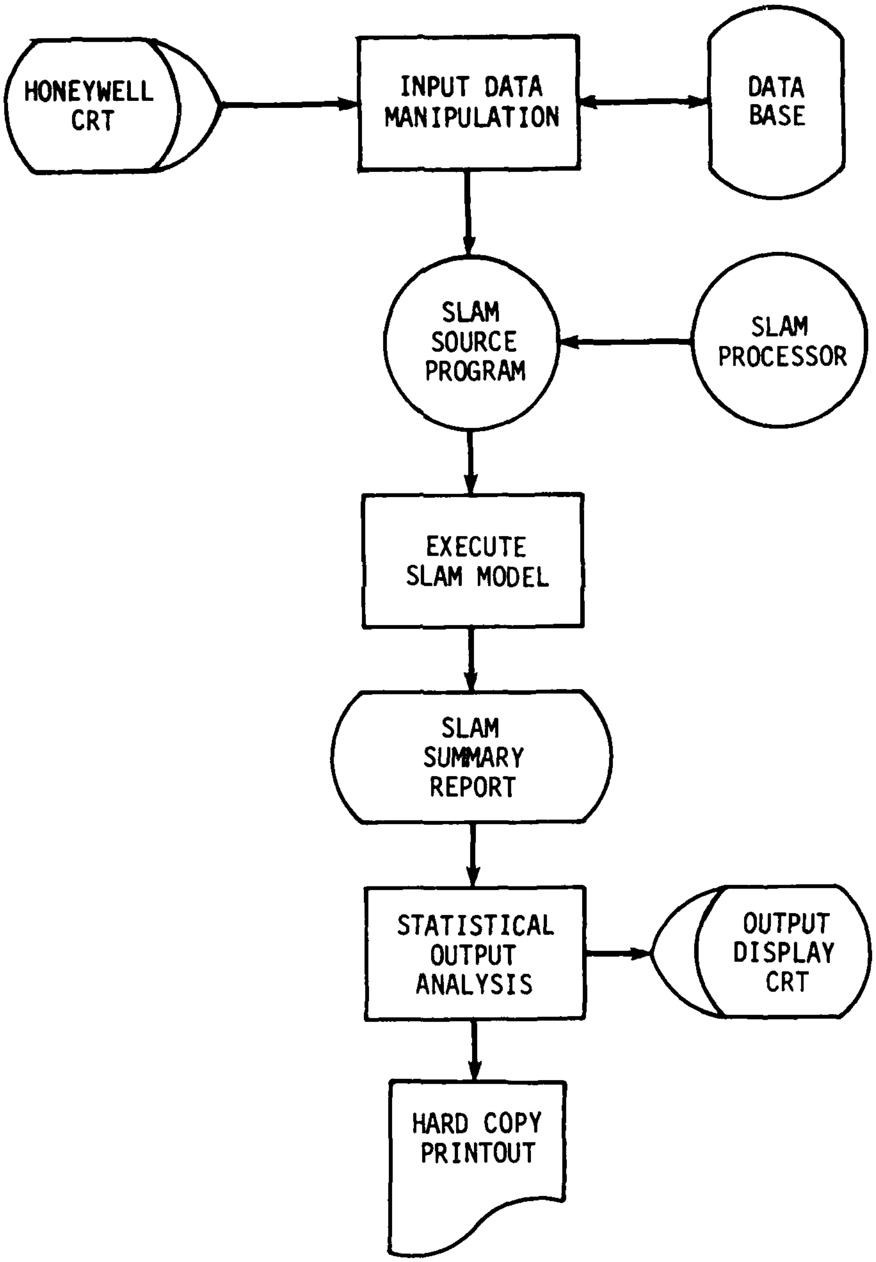


Figure 11. Interactive Mode of SLAM Model Operation

DEVICE 10H1 PROFILE. This file basically contains data elements which describe the transition phase from group-paced courses in the CNEWS curriculum to individualized training courses using Device 10H1. Eight configurations of the transition are included in the profile.

Device 10H1 is:

- not used
- used for phase I (Basic Operations) only
- used for phase II (Advanced Operations) only
- used for phase III (Tactical Operations and Watchstanding Exercises)
- used for both phases I and II
- used for both phases I and III
- used for both phases II and III
- used for phases I, II, and III.

By identifying the use of Device 10H1 with an appropriate function code, the model will automatically assume the proper transition phase from group-paced courses to individualized training courses. Therefore, the user does not have to look into the simulation model to verify any changes to be made every time he runs a different set of 10H1 transition phases.

INSTRUCTOR PROFILE. The instructor profile file is designed to store and update the number and types of instructors available to each course at the time the simulation run is made. As the Course Data Processing (CDP) code is a unique identifier, the code is used in the model as the key for instructor identification. The number and type of instructors available to each course are thus entered into the file according to CDP code. Whenever more than one CDP code represents the same course utilization, a new CDP code is created so that cross utilization of the same course by different types of students can be identified.

FACILITY STATUS PROFILE. The facility status file will contain only data elements such as various training devices, classrooms, and lab equipment which describe the current or anticipated status of various instructional resources available for individualized (self-paced) training courses. Since any changes in the use of instructional resources used for group-paced courses affect only class size and/or length variables, they are omitted from consideration.

COURSE DESCRIPTION PROFILE. The course description file contains the various course statistics required for use during the simulation. Specific input course data elements to be keyed in the file according to CDP code will include: the course length, the class size (group-paced courses only), the course convening frequency (group-paced courses only), and the student course attrition and setback rates.

For individualized courses, the course lengths will depend upon the individual student's performance. Thus, estimates of the minimum, maximum, and average times-to-complete for each course by the students will be required as inputs to the model instead of a single course length figure, as with group-paced courses.

INPUT STUDENT DISTRIBUTION PROFILE. The input student distribution profile maintains data elements regarding planned student inputs for each category of student. The projected number and onboard time of arrival at the school for each category of student flowing through the curriculum will be used in the model.

Throughout this report the central theme has been the utility of this model to the CNEWS; however, the model has application and usefulness to other Navy technical training schools. Although the initial model being developed addresses a training environment with a combination of group-paced and individualized training courses, it is transportable to situations where all courses also have some random events occurring which may affect the performance of the curriculum; i.e., fluctuation of the number of types of students and their arrival patterns. The model has value for such student flow simulation.

DEVELOPMENT AND EVALUATION PLAN

The preceding paragraphs delineated the overall objectives of the model that will be completed during phase II of the study. Phase II extends from September 15, 1979 to June 15, 1980 and is being conducted under a contract awarded to the Industrial Engineering Department at the University of Central Florida (UCF). Under the terms of this contract, UCF will develop a series of EW student flow models that will operate in the batched-process mode and which will be capable of operating on the Navy's UNIVAC 70/55 computer system. The contractor will also develop flow chart program documentation The plan being followed for this development is shown in figure 12. As can be seen, the contract portion of the study consists of five tasks. The first task is problem definition. This involves specifying the problem-solving objectives to be achieved by means of the model. The relevant model variables that will affect its performance and how those performances will be measured by the model are identified and defined.

The second task is model design and development. The development of the model consists of diagramming the student flows through the CNEWS curriculum into logical relationships in accordance with the problem solving objectives formulated in the problem definition task. The simulation model consists of both a static and dynamic description. The static description defines the elements of the model while the dynamic description defines the way in which the model elements interact with each other to change the students' flow through the curriculum over time and create the resulting impacts.

The computer program development and testing tasks are the third and fourth tasks in model development. The computer program will be developed using the SLAM model. Development and testing of the model's computer program will be accomplished by a team consisting of TAEG, Naval Training Equipment Center, and UCF personnel at the Navy Data Automation Facility.

Model testing will include a comparison of the model's output to the planned curriculum structures. Limited model development validation will be performed in conjunction with the model testing task.

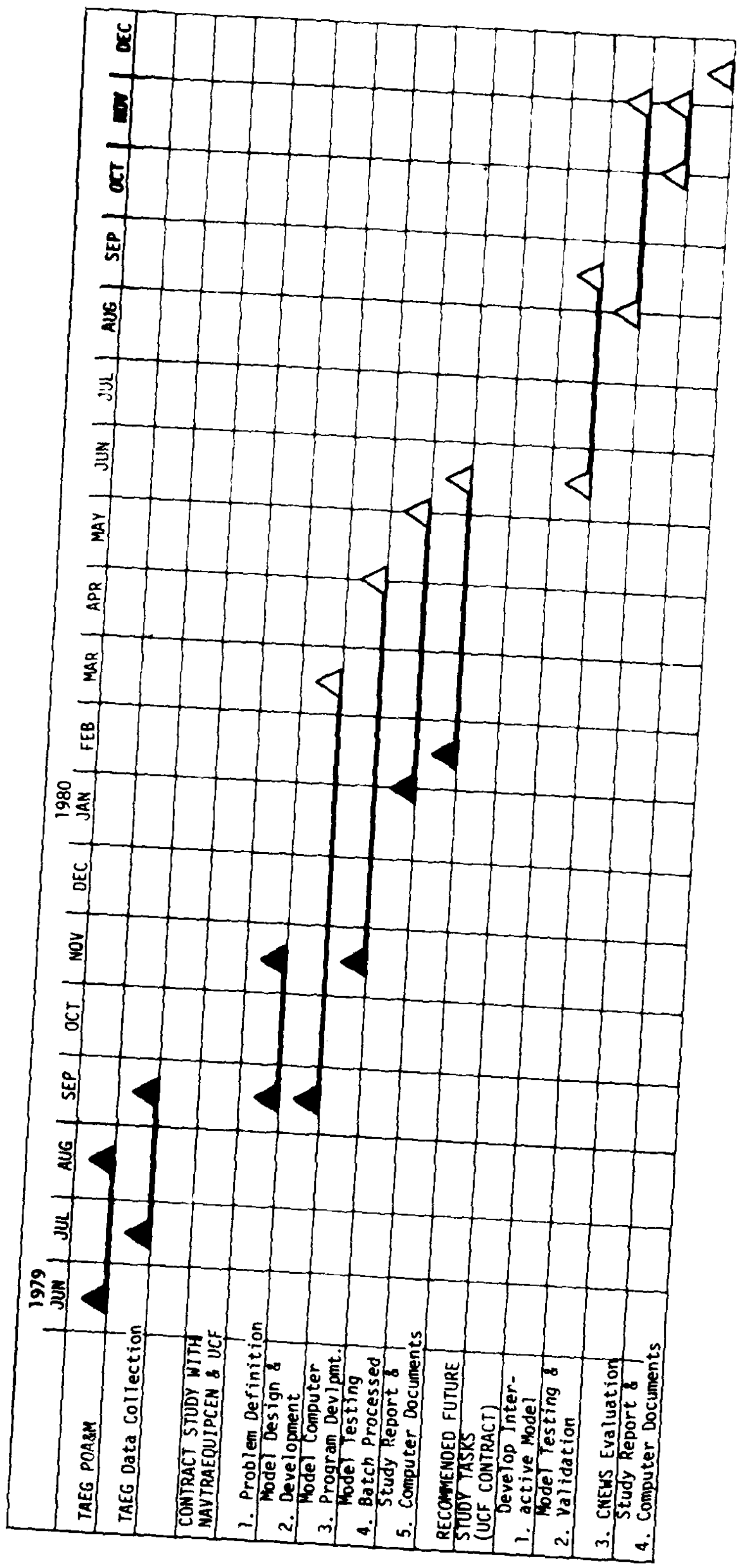


Figure 12. Electronic Warfare Student Flow Simulation Model Study Schedule

The final study task includes the development of model documentation. Documentation will include:

- development of a typical student flow scenario that can be solved by the model

- flowcharts and computer programs describing the model's operations.

Due to limitation of funds and time, several study objectives will not be achieved during phase II. A major goal for the study as previously stated was to have the model developed with an interactive capability for the user and to evaluate such a model at the CNEWS facility by December 1980. Subsequent study phases beyond phase II have been proposed by TAEG and are under consideration for funding by CNET.

SECTION V

POTENTIAL USES OF THE MODEL

This section discusses some possible uses of a student flow simulation model to Navy training planners if the goals of the present research study are achieved.

PLANNING/EVALUATION/IMPACT OF INCREMENTAL PROGRAMMING

Use of a student flow model by CNEWS planners could permit them to consider and test a variety of course combinations before a course or curriculum configuration is chosen for final development and implementation. In addition, the use of a student flow model should allow course planning to take place earlier and provide a means for more effective planning dialogue among individual course developers, course operations personnel, and CNEWS planners. The model should allow a larger number of curriculum design options to be considered in course and curriculum planning. It may also be possible to adapt future versions of the model to CNEWS management information system (MIS) efforts, and selected cost features could be developed for the model that could reflect the Navy's training resource acquisition and management policies and directives at the CNEWS operational level.

A significant advantage of the student flow simulation model for CNEWS planners is in modeling the implementation of the individualized EW operator curriculum and the introduction of the multistationed, generalized EW operator trainer, Device 10H1. This will include the ability to examine the impact on the curriculum of adopting new training technology and methods in the light of new training requirements.

The model should be of value to EW school curriculum planners in considering the impact of alternatives to meet changes in training requirements by providing insights into the likely impacts of such alternatives prior to having to make large and often long-term investments in time and resources. Insights obtained through modeling could include "optimizing" the change-over from lock-step to individualized portions of the curriculum. The "optimization" might take place in terms of altering course convening frequencies to minimize competition for available resources, or the identification of potential course conflicts so that alternatives could be considered such as course restructuring or the use of double shift operations for a limited time.

Since the EW school will be shifting from lock-step courses to individualized courses in the EW operator curriculum in a phased program over several years, the student flow model should provide insights into the likely impact of such an incremental program and the likely operational problems to be encountered when students exit from a lock-step course and enter an individualized course, or vice versa. This condition will occur during the next few years since the maintenance courses will remain lock-step for the near future and the operator training courses will be incrementally converted to individualized courses. The model will also provide forecasts of the likely effects of establishing and operating dual pipelines for a period of time during such a changeover.

USE WITH OTHER NAVY TRAINING AND PERSONNEL DATA SYSTEMS

Other capabilities/information which the model could provide if appropriately modified include:

- the ability to input to or use inputs from other Navy training and personnel data processing systems
- identification of commonality at the course lesson level among or within the CNEW's curriculum
- determination of course convening frequency prioritization
- identification of potential course scheduling problems with provision of alternative approaches and their attendant advantages and disadvantages
- determination of the optimum number of students exiting from individualized courses that must be available before a group-paced course is started
- determination of the most effective instructor-student ratio for operating various sizes and types of learning centers
- determination of the effects of phasing out courses of instruction
- forecast of the effects on manpower/resources caused by the operation of individualized courses.

APPENDIX A

DEVICE 10H1 DESCRIPTION

This appendix provides a short description of Device 10H1 and the types of EW training it provides.

Device 10H1 is a computer-controlled, generalized device which provides operator training in electronic support measures (ESM) and electronic countermeasures (ECM). The device provides computer-aided training in general system familiarization, operator skills development, operating techniques, EW capabilities and limitations, and EW watchstanding and tactical exercises. More than 20 operational EW equipments have been integrated into generalized equipment suites which provide basic EW training that is readily transferred to subsequent equipment-specific surface, subsurface, and airborne EW systems.

The device is modular in design and consists of 60 student stations which operate as independent trainee units, or in groups for team training, selectable by instructor/operator action. Table A-1 illustrates seven types of generalized EW suites simulated by Device 10H1, typical Navy platforms which carry these type equipment, equipments that comprise such suites, and the generic equipments and display functions for which Device 10H1 provides training.

TABLE A-1. DEVICE 10H1 EW SIMULATION

	Manual EW Surface	Automatic Surface	Automatic Surface ECM	Automatic Surface ESM	Automatic Air	Air Elint	Tactical Air
Typical Platforms	DD963	Destroyers Cruisers	Carriers	Submarines Carriers	EA6B	EP-3E	F-14 F-18
Typical Equipment	WLR-1 ULQ-6 IFM RBOC	SLQ-32	SLQ-17	WLR-8	ALQ 941 ALQ 92 ALQ 126 ALE 29	ARGOS IFM ALR 52	ALR 45/50 ALQ 126 ALE 41/37 ALE 29
Generic Equipments	Tunable superhetero-dyne re-ceiver with direction finder. Deception repeater antenna & direction indicator. Instan-taneous frequency monitor. Surface launched craft.	Automated threat reactive system for deception jammer.	Automated threat reactive system for deception jammer.	Automated surveillance receiver.	Tactical jammer. Communi-cation jammer. Deception jammer. Air drop chaff.	Instan-taneous fre-quency monitor. Tunable super-hetero-dyne receiver with direction finder.	Warning/ receiving deception jammers. Air drop chaff.
Displays	Activity video. Analysis video. Direction finder video. PRF numeri-cal. Frequency (IFM). PPI (chaff effect).	Alpha-numerical tactical data.	Alpha-numerical tactical data.	Alpha-numerical tactical data. Activity video. Analysis video.	Alpha-numerical tactical data. Analysis video. Direction finding.	Frequency polar (IFM) PRF numeri-cal.	Numerical warning of strobe displays.

APPENDIX B

A BRIEF SURVEY OF SIMULATION LANGUAGES

This appendix contains a description of the major simulation languages discussed in section III and depicted in figure 8.

PROCESS-ORIENTED SIMULATION LANGUAGE

Process-oriented simulation can be viewed as a single item, material, or person flowing through a system, which is operated on, then moved on to the next process. This type flow is well suited to such problems as student flow and material handling flow.

GPSS III AND GPSS/360. General Purpose System Simulation (GPSS) is a process-oriented simulation language for modeling discrete systems. GPSS is oriented toward problems in which items pass through a series of processing and/or storage functions. GPSS III is less general than GPSS/360. The language is limited in computing power and lacks a capability for floating point. The GPSS simulation clock is integer valued. This means that changes in the state of the system can occur only at integer points in time. It also means that when simultaneous events frequently occur the tie-breaking mechanism takes on added significance.

Q-GERT. Queue-Graphic Evaluation and Review Techniques (Q-GERT) is a network-oriented simulation language which is FORTRAN based. It employs an activity-or-branch network philosophy in which a branch represents an activity that models a processing time or delay. Nodes are used to separate branches and to model milestones, decision points, and queues.

EVENT-ORIENTED SIMULATION LANGUAGE

Event-oriented languages describe simulation problems that move from event-to-event. In this category, there are two representative simulation languages.

SIMSCRIT. A complete language oriented toward event-to-event simulations in which discrete logical processes are common. The principal appeal of SIMSCRIT is its English-like and free-form syntax. In SIMSCRIT the state of the system is defined by entities, their associated attributes, and by logical groupings of entities referred to as sets. There are two types of entities, permanent and temporary.

GASP IV. General Activity Simulation Program (GASP IV) is a set of subroutines in FORTRAN IV that performs functions useful in simulation. GASP IV provides a conceptual framework and supporting routines for writing discrete event, continuous, and a combined discrete event continuous simulation.

CONTINUOUS SYSTEM SIMULATION LANGUAGE

This part of the section discusses two types of continuous system simulation language. This is a class of equation-oriented language which is useful for modeling systems described by differential equations.

CSMP. Continuous System Modeling Program (CSMP) is a complete language oriented toward the solution of problems stated as nonlinear, integral-differential equations with continuous variables. Example: CSMP permits a digital computer to simulate an analog computer. The language is not widely used but is quite useful in specifying simulation procedures for specific types of problems. It was developed for defining models for engineering design applications.

DYNAMO. Dynamic Modeling (DYNAMO) is similar to CSMP in that it is oriented toward problems formulated in terms of nonlinear differential or difference equations, but it differs from CSMP in that it was developed for defining models of industrial, business, macroeconomic, and social systems.

APPENDIX C

A SLAM MODEL OF A HYPOTHETICAL EW OPERATOR TRAINING SITUATION

The SLAM model described below is intended to illustrate how one can apply the network modeling concepts to the complicated situations of individualized training. It is not intended to model the exact nature of the CNEWS operator curriculum developed in section III of this report.

HYPOTHETICAL MODELING SITUATION

It is desired that the CNEWS wants to provide individualized instruction to its EW operator students. In an individualized course, each student proceeds through a prescribed course of instruction at his own level of learning or mastery. Within the CNEWS operator curriculum, there are three phases of training taken sequentially by the students.

As an initial step, CNEWS might plan to introduce the operator training with individualized instruction in phase I only, while phases II and III are still convened as group-paced instruction. Under the self-paced instruction of phase I, each student goes through the training track by interacting with learning resources such as learning centers, classroom lectures, and training devices such as Device 10H1. The student would complete the academic portion of the course and then move on to Device 10H1. Once the student completes both the academic and Device 10H1 portion of phase I, he completes a criterion performance test and proceeds to phase II. If the student has difficulty in any part of phase I training, he is remediated and then continues on his training path.

SLAM MODEL

Assuming some hypothetical numerical input data and using the SLAM notations and symbols, the SLAM graphical model for the EW operator training system described above is depicted in figure C-1. Entities representing the EW students are created at the CREATE node with the time between entities specified to be exponentially distributed with mean of 0.5 time units, and only 1,000 of them are to be created. Each entity's first attribute (ATRIB(1)) is marked with its time of creation at the CREATE node. The entity is sent to the first QUEUE node labeled LC, which is used to represent the waiting area for the learning carrels. The parameters for this QUEUE node specify that the queue is initially empty, has no waiting capacity limit, and that entities waiting in the queue are placed in file 1. Fifty parallel learning carrels are represented by activity 1 emanating from the LC node with the service time (usage time) specified as uniformly distributed between 6 and 10 time units.

Following completion of programmed instruction at the LC, the entity attempts to enter the second QUEUE node labeled 10H1 which is used to model the waiting line for 10H1 devices. The parameters for this node are essentially the same as those of LC node except the fact that entities waiting in the queue are placed in file 2. Twenty parallel 10H1 devices are represented by activity 2 and a student's occupancy time specified by a triangular distribution with time estimates of (15,20,25) for a minimum, average, and a maximum.

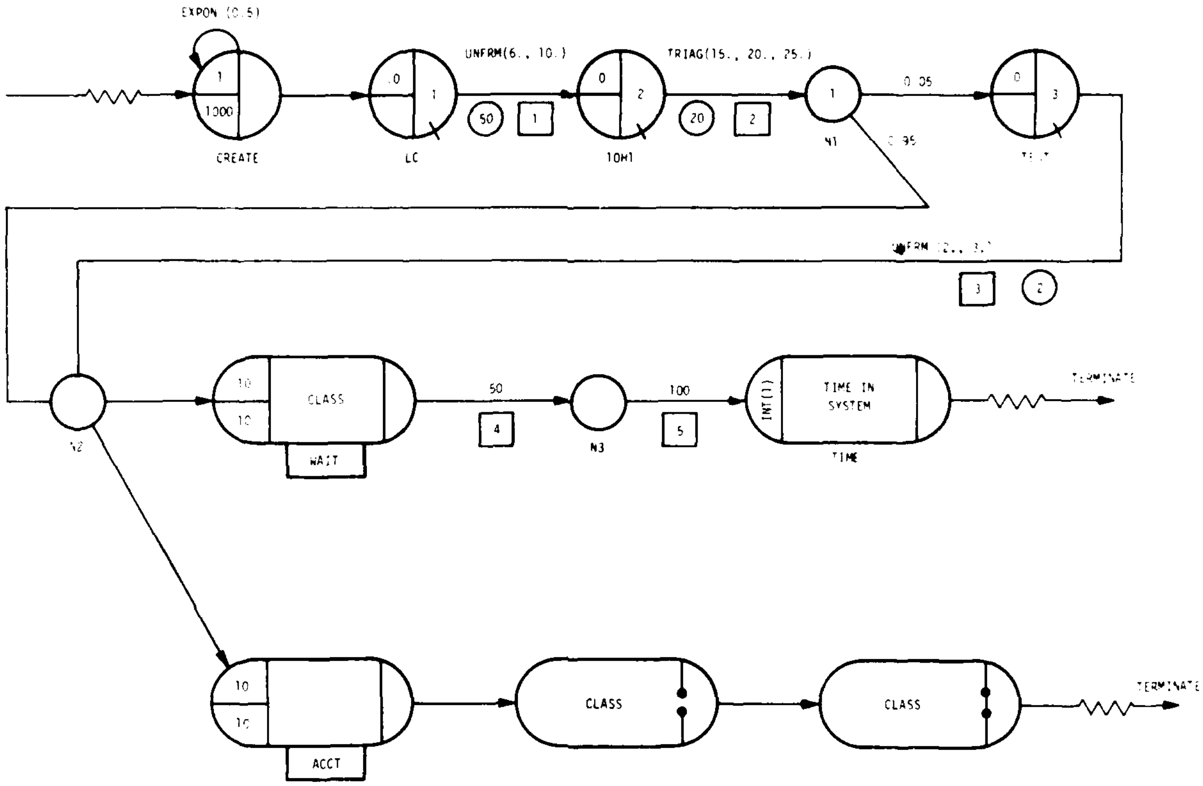


Figure C-1. Hypothetical Example of a SLAM Network Model

Following completion of 10H1 device activity, the entities arrive at a GOON (go-on) node labeled N1 where they are probabilistically routed. That is, 5 percent of the incoming entities to node N1 are routed to the third QUEUE node labeled TEST, while the rest of them are routed to the node N2. One activity leads to the AWAIT node labeled WAIT putting entities into a holding node until a prescribed number of entities have arrived at it. This holding node represents a group of students waiting for phase II to be convened. The class size limit for phase II is set to 10 students so that whenever the number of incoming entities to the ACCT node reaches 10, the ACCT node is released which causes gate CLASS to be opened. When this happens, the students waiting in WAIT node will be removed to node N3. The other activity leads to the QUEUE node named TEST representing the waiting line for remedial instructions for the students who failed to pass the exam. Entities in the TEST node wait for the instructor in file 3. The special instructions are given by two parallel training instructors whose instructional time duration is uniformly distributed between two and three time units. Following remedial instruction, entities are routed to N2 node.

Activities 4 and 5 represent the instructional time required to complete phases II and III respectively under the group-paced lock-step training system. It requires 50 time units to complete phase II and 100 time units for phase III. Upon completion of phase III, the entity proceeds to a COLCT node labeled TIME where INT (1) statistics are collected on the interval of time between the time recorded in attribute 1 of the entity at the CREATE node and the current simulated entity in the system. Following the COLCT node, the entity is terminated.

SLAM STATEMENTS

Once the graphical representation of the system is completed, the next step in the modeling process is to transcribe the graphical representation of the system into the equivalent SLAM statement representation according to the appropriate format specifications. The input statements corresponding to the network in figure C-1 are listed in table C-1.

As can be observed above, the use of SLAM simplifies the programming effort to a minimum as compared to other simulation languages. The complexity of the simulation model of the EW student flow is rather extensive considering 24 types of student tracks and 14 separate pipelines; thus, the selection of an effective simulation language to simulate such a system becomes further pronounced.

TABLE C-1. HYPOTHETICAL EXAMPLE OF A SLAM STATEMENT

```
NETWORK
          CREATE, EXPON (0.5),,1,000;
          QUEUE (1);
            ACTIVITY(50)/1, UNFRM (6,10.);
          QUEUE (2);
            ACTIVITY (20)/2, EXPON (20.);
          GOON:
               ACTIVITY,,.5, N2;
               ACTIVITY,,.95, TEST;
TEST QUEUE (3), 2;
               ACTIVITY(2)/3, UNFRM (2.,3.), N2;
N2        GOON;
               ACTIVITY,,,WAIT;
               ACTIVITY,,,ACCT;
WAIT AWAIT (4), CLASS;
               ACTIVITY/4, 5Ø,,N3;
N3        GOON;
               ACTIVITY/5, 1ØØ;
TIME COLCT, INT(1), TIME IN SYSTEM;
          TERM;
ACCT ACCUMULATE, 1Ø, 1Ø;
          ACTIVITY;
          OPEN, CLASS;
               ACTIVITY;
          CLOSS, CLASS;
          TERM;
          END;
```

Note: GOON = go-on

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